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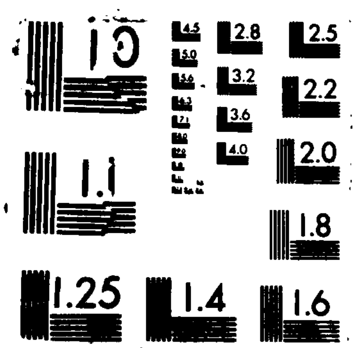
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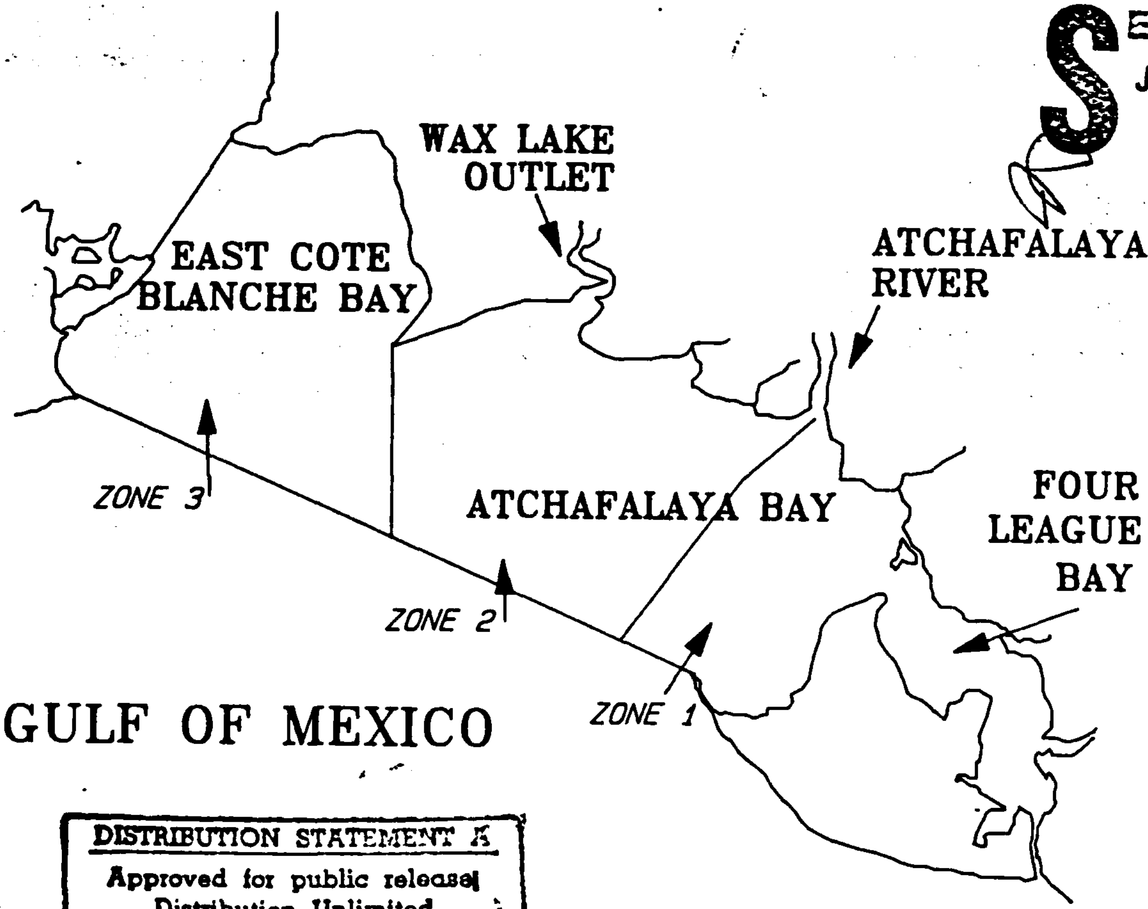
US Army Corps
of Engineers
New Orleans District

April, 1987

OYSTER SHELL DREDGING IN ATCHAFALAYA BAY AND ADJACENT WATERS, LOUISIANA



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Oyster shells have been removed by means of hydraulic cutter-head dredges from the waters of coastal Louisiana since 1917. The shells have been harvested primarily for use in construction activities, although a variety of other uses are common. There has been considerable controversy over the impacts of shell dredging. This Draft Environmental Impact Statement has has been prepared to assess the impacts of oyster shell dredging in East Cote Blanche Bay, Atchafalaya Bay, and Four League Bay, Louisiana as (over)

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permitted under 5-year permits issued in 1982 that will expire in December 1987. The document also assesses the impacts of applications for 10-year permit extensions that would allow continuation of dredging under the same conditions. These permit actions are being considered under the authority of the Section 10 of the River and Harbor Act and Section 404 of the Clean Water Act. Numerous alternatives have been discussed and evaluated in the document. Keywords:

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(Draft Environmental Impact Statement)

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Oyster Shell Dredging in Atchafalaya Bay
and Adjacent Waters, Louisiana

The responsible lead agency is the U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana.

This DEIS assesses the impacts of oyster shell dredging in East Cote Blanche Bay, Atchafalaya Bay, and Four League Bay, Louisiana, as permitted under 5-year permits issued in 1982 and expiring in December 1987. The document also assesses the impacts of applications for 10-year time extensions that would allow the continuation of dredging under the same conditions. Applicants for the permits and extensions are Dravo Basic Materials Company, Inc. and Lake Charles Dredging and Towing Company, Inc. These permit actions are being considered under the authority of Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act.

Abstract: Oyster shells have been removed by mean of hydraulic cutter-head dredges from the waters of coastal Louisiana since 1917. The shells have been harvested primarily for use in construction activities, although a variety of other uses are common. There has been considerable controversy over impacts of shell dredging, and this document has been prepared to assess those impacts. Numerous alternatives have been discussed and 5 alternatives are examined in detail.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY: June 8, 1987

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S.1. DESCRIPTION OF PROPOSED ACTION

The dredging of oyster shell as a source of construction aggregate and calcium carbonate has been an active industry in the East Cote Blanche/Atchafalaya/Four League Bay area since 1914. At that time, removal of shell resources from the massive Point Au Fer Shell Reef was allowed and, in effect, encouraged by existing state regulations. The many restrictions which have been established since that time are listed as Appendix B. These restrictions have developed over the last 70 years as a result of interactions and compromise between the shell dredging industry and various regulatory agencies. Existing restrictions and regulations permit only the removal of submerged (buried) reefs, most of which are covered with a three to eight foot overburden of silt and clay.

Environmental Assessments were prepared by the U. S. Army Corps of Engineers (USACE) in 1982 and 1984 to identify the impacts associated with the removal of buried shell in the coastal waters of Louisiana. In April, 1986, the USACE was ordered by the United States District Court, Eastern District of Louisiana to prepare an Environmental Impact Statement(s) (EIS)(s) on those areas for which shell dredging permits had been issued (Zones 1-9 as shown on Figure 1). This EIS addresses only the impacts of shell dredging in the East Cote Blanche/Atchafalaya/Four League Bay area (Zones 1-3). This involves only the permits that have been issued to DRAVO Basic Materials Corp. and Lake Charles Dredging and Towing Company. Preparation of the additional EIS(s) on the remainder of the currently permitted areas (Zones 4-9) will continue. Existing permits covering those areas will not be renewed until an EIS has been prepared in accordance with the court order.

S.2. SUMMARY OF MAJOR ALTERNATIVES

During the scoping process, several general alternatives were identified for consideration in this EIS.

Five alternatives were selected for the detailed consideration of environmental, social, and economic factors. They are as follows:

ALTERNATIVE 1- RENEW PERMITS WITH EXISTING CONDITIONS

ALTERNATIVE 2- PERMIT DENIAL (NO ACTION)

ALTERNATIVE 3- RENEW PERMITS WITH EXISTING CONDITIONS, BUT CLOSE BOTTOM HALF OF FOUR LEAGUE BAY TO DREDGING ACTIVITIES (CLOSURE OF BOTTOM HALF OF FOUR LEAGUE BAY)

ALTERNATIVE 4- RENEW PERMITS WITH EXISTING CONDITIONS, BUT REDUCE WIDTH OF ZONE RESTRICTING DREDGING NEAR SHORE IN UPPER HALF OF FOUR LEAGUE BAY FROM 0.5 MILES TO 1500 FEET (REDUCE SHORELINE RESTRICTIONS IN UPPER FOUR LEAGUE BAY)

ALTERNATIVE 5- RENEW PERMITS WITH EXISTING CONDITIONS, BUT REDUCE DREDGING INTENSITY TO ALLOW A MAXIMUM OF TWO DREDGES IN WESTERN EAST COTE BLANCHE BAY (REDUCE DREDGING INTENSITY IN WESTERN EAST COTE BLANCHE BAY)

S.3. SUMMARY OF ENVIRONMENTAL IMPACTS

S.3.1. Introduction

Many impacts have been attributed to shell dredging operations, both in Louisiana and other states. In the coastal areas of Louisiana, large amounts of shell (both clam and oyster) are located within the permitted regions, and are available as a resource for industry if permitted by the proper regulatory agencies.

S.3.1.2. Shell Reserves of Project Area

Use of estimates and numbers provided by representatives of the shell dredging industry has been critical to the preparation of this document and assessment of the duration of impacts. One method of determining the life of the industry is the use of estimated reserves in the project area. Current annual production rates of approximately 3.0 million cubic yards (MCY) were used to assess the duration of impacts. Proven, mapped reserves total 6.2 MCY within the currently permitted areas of East Cote Blanche Bay at current removal rates, there is an expected 2.1 years of shell dredging activity in that region. In Atchafalaya Bay, under current permits and extraction rates, the 5.875 MCY would allow for 2 years of dredging. With the current 0.5 mile distance requirements from shore, the shell reserves in Four League Bay have been reported at 3.15 MCY. However, if the restriction in the northern half of Four League Bay was reduced to 1,500 feet from shore, an additional 2.5 MCY would be available for use. However, these figures are estimates, based on gross surveys of the region. More detailed figures are not available, and representatives of the shell dredging industry have stated "This volume (proven reserves) reflects only a small percentage of what industry geologists believe to be the total shell reserves in the areas permitted for dredging."

S.3.2. Summary of Endangered Species Impacts

An endangered species assessment (Appendix A) has been prepared following coordination with required Federal agencies. Two species were identified with potential of being impacted by shell dredging activities, Kemp's (Atlantic) ridley turtle (Lepidochelys kempi) and the loggerhead sea turtle (Caretta caretta). Neither species has been sighted in the immediate vicinity of the shell dredges and the potential for adverse impact has been judged to be negligible. The National Marine Fisheries Service has concurred with the assessment.

S.3.3. Summary of Biological Impacts

The biological impacts of the removal of buried shell resources within the coastal region of Louisiana are considered to be temporary and localized. Each working dredge directly disturbs approximately 1.2 acres of shallow waterbottom per day. With only 2 operating dredges, this represents approximately 875 acres annually. This is equivalent to roughly 0.5 percent of the total permitted waterbottoms of the project area. The maximum permitted operating conditions is four dredges operating 365 days a year, directly impacting 1,750 acres of waterbottom. However, four dredges have not operated at one time since 1983, and the average amount of time dredges operate, allowing for machinery failure and transit time, is approximately 65 percent. Thus, if maximum dredging time were attainable, only 0.73 percent of the total (or 1.05 percent of the permitted) waterbottoms of the project area would be impacted annually.

Dredging of buried shell has the most dramatic impact on the benthic animals whose existence is dependent on the sediments. These organisms are destroyed, and the sediment discharged following the removal of the shell spreads beyond the boundaries of the pit from which shell was taken. This "fluid mud" has the effect of smothering an undeterminable percentage of the benthic animals in a limited area around the dredge. Studies have shown that initial recolonization of the affected area by resident benthic taxa occurs within three months, and a benthic community, which is often indistinguishable from communities in adjacent sediments, should be established within 2 years. Impacts of the locally increased turbidity levels are also temporary, and in a naturally turbid system, often inseparable from those attributable to natural sources. The more mobile fish populations leave the areas of highest turbidity and are minimally impacted. Holes and troughs which result from the removal of buried oyster reefs may provide a place of refuge for fish during the passage of cold fronts. Impacts to live oyster beds, a valuable resource, are minimized by restrictions which prohibit the operation of

shell dredges within a 1,500-foot wide buffer zone from shore, and 1,500 feet around exposed reefs.

S.3.4. **Summary of Hydrological Impacts**

In general, the hydrological effects of shell dredging on the coastal environment are short term and localized in extent. Under existing operating conditions, the effects of the removal of buried shell are minimal, as distance restrictions currently minimize any hydrological impacts to the shoreline. The holes and troughs which result from dredging operations fill over varying periods of time, depending largely on location, coastal processes at that site, and proximity to sediment sources. Dredge holes and shell barge access channels last longer and will have a more pronounced impact in areas where riverine and tidal processes combine to create natural scour. Areas such as eastern Atchafalaya Bay, between the mouth of Four League Bay and Point Au Fer Reef, and the area between the Wax Lake Outlet and the Atchafalaya Delta lobes, are examples of persistently scoured areas in Atchafalaya Bay. The impacts of the dredge holes and troughs on average wave heights and storm surge wave heights (including hurricanes) are negligible.

S.3.5. **Summary of Geological Impacts**

From a geological/geotechnical viewpoint, the removal of the buried shell resources from below the shallow bay bottom has a negligible effect on the formation of new deltaic lobes and the filling of the bays by the riverborne deltaic sediments. Holes and troughs which are the result of the removal of the buried resources, are filled largely with reworked material from adjacent waterbottoms.

S.3.6. **Summary of Water Quality Impacts**

The primary effect of shell dredging on water quality is a temporary increase in turbidity and suspended solids levels. Concentrations of nutrients, such as nitrogen and phosphorus, could be temporarily elevated

in the immediate vicinity of the dredging. This increase is short-lived and not considered significant in relation to the size of the area involved. Dredging does not significantly degrade water quality, and the data available indicate that biomagnification of contaminants in marine food webs is not a problem. Turbidity impacts are temporary and localized. With four dredges operating, less than 2% at any one time of the project area waterbodies are impacted at any one time by dredge-generated turbidity significantly above background levels.

S.3.7. Summary of Cultural Impacts

Regulations exist which require the operators of the shell dredges to report the occurrence of any artifacts of historical or archeological interest (ship fittings, timbers, pottery, bone, etc.) to the appropriate agencies. If artifacts are discovered, all dredging activities in that area will cease until approval is given clearance to proceed by USACE, pursuant to consultation with the State Historic Preservation Officer (SHPO).

S.3.8. Summary of Recreational Impacts

Impacts to the recreational use of the coastal waters within the project areas of the East Cote Blanche/Atchafalaya/Four League Bay system are minimal. Currently, there is low recreational use of the waters within the project area when compared to other water bodies in coastal Louisiana. The general inaccessability of the project area and low population densities of surrounding lands has kept recreational efforts far below that of other regions.

S.3.9. Summary of Economic Impacts

The economic impacts of shell dredging extend throughout the coastal area. Of major importance is the use of shell for construction and maintenance material for roads in coastal Louisiana. Shell provides the most economical source of aggregate due to the high transportation costs

of other aggregate. Shell dredging also provides jobs and income to those directly involved, as well as in related fields, who depend to some extent upon shells. Royalties and severance taxes collected by state agencies are used to provide public services. These revenues would not be available to the state from substitute products. If shell dredging were discontinued, these favorable economic impacts would be lost to the State of Louisiana. However, the losses would be offset somewhat by growth in other states which supply alternate materials.

S.3.10. **Summary of Social Impacts**

The most beneficial social impacts of shell dredging are those related to community cohesion and community growth. Employment and income generated directly by the dredging industry, plus jobs and attendant income of those dependent to some degree upon the industry are important factors to the well being and growth of the community.

Two negative social impacts associated with shell dredging are increased noise and turbidity, which can be found in a localized area around the dredge. However, since the existing permit restrictions preclude dredging within one-half mile of the shoreline, these adverse impacts are experienced only by those on or nearby the dredge.

S.3.11. **Summary of Cumulative Impacts**

A variety of human activities in the coastal region, of which shell dredging is only one, have contributed to the environmental alteration of the estuaries of the East Cote Blanche/Atchafalaya/Four League Bay system. Changes in water quality occur from introduction of inadequately treated and raw domestic wastes from Houma and Morgan City as well as numerous small communities, discharges of fish and shellfish industries, contributions from oil and gas exploration and production, and urban and agricultural runoff. Actual operation of recreational and commercial shrimp trawls in small embayments directly affects benthic and epibenthic fish and invertebrates as well as increases turbidities with suspended

sediment concentrations in the vicinity of trawling operations equivalent to those in the vicinity of channel maintenance dredges.

Various construction activities are permitted by the USACE in the coast and include oil related activities (canals, pipelines, structures), dredging and filling activities, mooring facilities, bulkhead, and levee construction. Long term effects of such activities may include saltwater intrusion, land loss, loss of marsh habitat (change in marsh type or conversion to open water) and subsequent decrease in biological productivity, and alteration of hydrologic characteristics.

Short term construction impacts include localized changes in water quality such as increased turbidity, reduced dissolved oxygen concentrations, and release of nutrients and contaminants from sediments as well as direct loss of organisms when water bottoms are dredged. Impacts of an oil spill has both long and short term implications.

The environmental impacts of each type of project are evaluated in project specific EIS's and are often similar to those outlined for construction projects in general.

S.4. SUMMARY OF MITIGATION MEASURES

Recommendations for offsite mitigation of possible shell dredging impacts are prescribed under present regulations. These mitigation measures involve construction of a shell reef, one-foot thick, and one acre in size for every 200,000 cubic yards of material removed from the bays. Implementation of this measure is at the discretion of the Secretary of the Department of Natural Resources for the State of Louisiana. A single reef approximately one acre in size has been built in the vicinity of Cypremort Point as a result of this regulation.

S.5. **Summary of Judicial Requirements**

This EIS makes an effort to assess the impacts of oyster shell dredging on all of the significant resources and issues which surfaced during litigation and during the scoping process. In the April 1986 court opinion, the United States District Judge ordered that the coastal area EIS(s) shall, at a minimum, analyze the possible impacts of shell dredging on several areas of concern. These concerns are listed below, accompanied by a description of where and how these items are discussed in the EIS and appendixes.

a. The Emergence of the Atchafalaya Bay Delta - The emergence of the Atchafalaya Bay Delta is of great interest to many individuals, and biological and physical factors which may affect it are discussed at length throughout the EIS and appendixes. Section 3 of this EIS, in particular, discusses existing conditions and impacts of shell dredging on the delta. Additional information regarding the impact of holes and troughs on the region is presented in Section 3.4.1.3. and Appendix C.

b. Water Quality - Discussions regarding the water quality and the impacts of shell dredging on it are presented in Section 3.4.2.2. of this document. Appendix C provides additional technical information regarding water quality.

c. Shell Reefs - The presence of widespread oyster reefs in the project area, both live and dead, is addressed in Section 3.5.2.3. Additional technical information regarding oyster reefs has been provided in Appendix D.

d. Sport Fishing - The impact of shell dredging activities on sportfishing and other recreational opportunities of the project area is present in Section 3.7.2. of this EIS.

e. Storm Waters in the Gulf of Mexico - The presence of holes and troughs which result from the removal of shell resources are thought by

some interested parties to affect the magnitude of storm waters in the Gulf of Mexico. This, in turn, is thought to affect the coastal regions of the project area. The impact of shell dredging on the hydrology of the project area is discussed in Section 3.4.1.2. and again in Appendix C of this document.

f. Exhaustion of the Shell Resource - The depletion of fossil shells is discussed in this EIS in Section 3.6. (Economic Environment). It is estimated that reserves of fossil shells in all of the project area are sufficient to sustain dredging at current levels for about 6 years under the current restrictions. However, estimates of reserves are not exact and great amounts of economically retrievable, unverified shell is suspected within the currently permitted areas. In addition, considerable known reserves exist in areas which have been closed to shell dredging under current permits.

1. PURPOSE AND NEED FOR PROPOSED ACTION

1.1. STATEMENT OF PURPOSE AND NEED

With regard to the private need, the applicants must obtain a Department of the Army permit under Section 404 of the Clean Water Act to continue removing shell and to remain a viable industry. The public need is the continuation of the use of shell in the variety of purposes. The oyster or reef shell that is dredged from the shallow waterbottoms of the project area is used as a readily available source of calcium carbonate and aggregate for basic raw materials to industry. The bulk of this shell is used in general construction as highway base course, fill material, levees, parking lots, and road surfaces. Lesser amounts of shell go into Portland cement, mortar, petroleum and chemical products, lime, water purification, agricultural lime, chicken feed, glass, and pharmaceuticals. Since 1975, an average of approximately 4 million cubic yards (MCY) of reef shell have been harvested from the coastal regions of Louisiana (Figures 2 and 3).

The shell dredging industry provides direct and indirect employment opportunities for hundreds of Louisiana residents. In addition, the industry generates money for the State of Louisiana in the form of royalties and taxes on both the income of employees and sales of products.

1.2. HISTORY OF SHELL DREDGING IN COASTAL LOUISIANA

Shellfish have historically been very common within the coastal waters of Louisiana and have served as a primary source of food for wildlife and early inhabitants. The common oyster and *Rangia* clam shell are the basis of most of the hundreds of shell heaps or "middens" found throughout the coastal regions of the southeastern United States. These middens range as high as twenty feet in some areas and served as both habitation sites and burial grounds for prehistoric peoples. The middens are commonly attributed to the Archaic Period (ca. 8000-500 B.C.) and are

often marked today in coastal regions of Louisiana by the presence of a line of live oaks rooted in submerged shell middens.

The first shell dredging lease granted in Louisiana was in 1914 for an area near Point Au Fer Reef, a massive protective reef of oyster shell which runs roughly parallel to the coastline at the southern extremity of Atchafalaya Bay. This lease and the shell dredging industry as a whole was developed as an income source for the Conservation Commission, the forerunner of the present-day Louisiana Department of Wildlife and Fisheries (LDWF). The first lease, granted to a Mr. Alfred Meade, was an exclusive lease on a comparatively small amount of water bottom. Later, this lease and those to come became larger in size and greater amounts of revenue were generated for the LDWF. The scope of the shell dredging industry advanced rapidly with nearly all of the western Louisiana bays, almost all of Barataria Bay, and large portions of Chandeleur Sound and Lake Borgne leased for removal of oyster and clam shell. These exclusive leases began to come under a closer scrutiny by the late 1930's as opposition to dredging activities in the vicinity of live oysters began to develop. Around 1939, leases in Barataria Bay close to live oysters were revoked.

Annual production of shell from the waters of Louisiana has varied greatly, as shown by records which have been kept since 1917. These figures, however, often represent demand for shell and not ability of the industry to recover the resource. Production of oyster shells from coastal waters have fluctuated widely from a low of 200,000 cubic yards in 1918 to a high well in excess of 4 million cubic yards between 1967 and 1975. The average annual production (4,113,745 cubic yards) for the past ten years (1975-1985) has shown a decline from the earlier high production values.

Current production is approximately 3 MCY annually. Average royalties paid to the State of Louisiana during this period are in excess of $800,000 annually (Figure 4).

1.3. DESCRIPTION OF SHELL DREDGING TECHNIQUES

Shell dredging within the central coast of Louisiana centers around removal of reef oyster shell that is buried beneath one to eight feet of sediment, called overburden. This burial is the result of the constant inflow of sediment-laden fresh waters and movement of sediments along the coast. Oyster reefs were formed over a period of thousands of years as the Mississippi River shifted from one deltaic system to another, forming a dynamic environment and providing an extremely large estuarine system along the coast. Viable reefs formed in regions of optimal production, older reefs died as conditions deteriorated. This resulted in the widespread distribution of fossil oyster reefs in the project area (Figure 5). These reefs are variable in thickness and range from small isolated patch reefs to those which cover hundreds of acres and contain millions of cubic yards of fossil shell. The thickness of these reefs vary from a few inches up to eight feet.

Removal of fossil shell is accomplished through a series of steps. The first is the identification of the location and extent of the buried reef. This initial effort is achieved by use of a small survey boat which outlines the buried reef by inserting a probe into the sediment. This probe, and the hand of the experienced surveyor, outlines the areal extent and thickness of the reef. Flags are set at the perimeter of the reef and a centerline is set along which the shell dredge moves. The time-consuming nature of this process does not allow for these detailed maps to be compiled far in advance of the actual removal of the shell and no maps exist which show the subaqueous reefs in detail.

The dredge then moves into an area previously defined by the survey boat and begins removal of the buried deposit. Occasionally a shallow, barge-access channel must be dredged from one reef to the next. This operation is infrequent, as the barges usually "lighten up" sufficiently to move to new areas. The dredges used in the coastal areas of Louisiana are basically barge-like in design, with an excavating cutterhead, suction ladder, pumping system, and a materials washing and screening

plant. These dredges are often self-propelled with a barge tied alongside to receive shells. As the dredge moves into a previously identified area, anchors are placed to either side and the cutterhead is lowered into the sediments. The overburden is the first material encountered, and is easily removed with the cutterhead and hydraulic pumping action. As buried reef is contacted, the rotating cutterhead breaks into cemented shell, which is then pumped on board for the screening process. The slurry of shell and mud is deposited onto flat sizing screens, where it is washed and shell material above the desired size (often three-eighths of an inch) is retained. This larger shell fraction is passed through a rotary washer, dumped to a conveyor belt and offloaded to a barge. Smaller shell (which passed through a three-eighths inch screen), is discharged into a screw washer. This finer fraction can also be dumped to a conveyor belt and loaded onto barges if required. Discharge of wash water, associated muds, and shell hash is through a gravity feed to two pipes which dump off the starboard and port stern of the dredge. Passage of this water and associated muds off the stern, and the orientation of the dredge within the center of the cut, allows for the dredged material to be reintroduced into the water column in the vicinity of the cut. Because of the fine nature of the sediments removed to gain access to the buried oyster reef, some amount of material remains in suspension for variable periods of time. This allows prevailing currents to transport portions of the finer material from the trench area and cover adjacent waterbottoms that would not otherwise be affected. The waterbottom, immediately following passage of the dredge, is a trench, perhaps in excess of 400 feet wide, with an irregularly shaped bottom of troughs and mounds. This bottom may be in excess of 10 feet below adjacent waterbottoms. The movement of the cutterhead is a continual side-to-side motion, advancing slowly at a rate of approximately 140 feet per day. This movement forward and laterally is achieved by the constant pulling in on anchor lines. This action allows the dredge to pivot on spuds, so that the resultant trench from which the shell is removed often averages 350 feet in width (Figure 6).

2. ALTERNATIVES

2.1. INTRODUCTION

During the scoping process, a number of alternatives were suggested, which were then grouped by type. Specific alternatives were developed to address those suggestions.

A thorough analysis must consider increased and decreased areal restrictions, as well as increases or decreases in dredging intensity and dredge discharge rates. It is not reasonable to completely ignore all of the effort expended by the Louisiana Department of Wildlife and Fisheries (LDWF), the Louisiana Department of Natural Resources (LDNR), and the U. S. Army Corps of Engineers (USACE) and attempt to develop an entirely new array of possibilities. For the purposes of this analysis, the existing condition is considered to be the operation of the industry under all of the present constraints, not just those imposed by the USACE.

The USACE permits include of the constraints of other regulatory agencies, and do not allow for the noncompliance of the permittee regarding the restrictions of the LDWF or DNR. In the instance where limitations of other regulatory agencies are more stringent, the permittee must comply with the more rigorous of the conditions. As an example, according to USACE restrictions, no dredging is allowed within 1,500 feet of the shoreline within the central coastal region. However, constraints placed by DNR do not permit dredging within 0.5 miles of the existing shoreline. The latter, more restrictive limit, must be complied with during all operations of the shell dredging industry. Figure 7 shows regions within the Project Area where shell dredging is prohibited.

2.2. DESCRIPTION OF ALTERNATIVES

2.2.1. Permit Denial (No Action)

This alternative has been developed as the baseline against which all other alternatives are compared. Permit denial assumes: 1) cessation of all shell dredging activities in the coastal area, and 2) that other materials would be acquired to fill the functional roles of the shell.

2.2.1.1. Alternative Materials

Thirteen alternative materials were investigated from an engineering viewpoint as potential substitutes for shell material and are compared in Table 1. In comparing these different materials, 11 different uses of shell were considered. The study indicated that of the 13 materials, six were eliminated on the basis that they were unacceptable as substitutes for shell on six or more uses. Gravel, limestone, recycled concrete, steel slag, and spent bauxite were eliminated on the basis that they possessed densities which were too high to be used as a substitute for shell when a light-weight material was a requirement. Elimination on the basis of too high density does not preclude the use of these materials as a substitute for shell in uses where density is not a factor. The two remaining materials investigated were sand and scoria. Scoria cannot be analyzed at this time because little data exist to compare the potential use of this as a construction material. Sand is borderline from a density standpoint since the range of densities for sand is dependent upon the need/no-need for light-weight material. Consideration of these materials centered around the physical characteristics of the materials, and not such parameters as: availability, costs at source, costs for delivery, availability of transportation, or transport/handling durability.

TABLE 1

Possible Shell Substitutes
(U.S. Army Corps of Engineers)

Material	Estimated Bulk Density (lbs/ft3) MIN	Estimated Bulk Density (lbs/ft3) MAX	Base Course	Bedding	Concrete Aggregates	Road Surfacing	Dike Cores	Dolphin Fill	Filter	Pervious Backfill	Subbase	Surcharge
			Current and Potential Uses									
Asphalt Concrete	135	155	*	X	X	X	X	*	X	X	X	X
Clay	110	165	*	X	X	A	X	X	X	X	*	*
Concrete	135	150	*	X	X	*	X	*	X	X	X	X
Florogypsum	65=		C	C	X	X	X	X	X	X	C	*
Geotextile	nil		B	*	X	X	X	X	*	X	B	X
Gravel	85	120	*	*	*	*	*	*	*	*	*	*
Limestone	90	150	*	*	*	*	*	*	*	*	*	*
Phosphogypsum	70=		C	C	X	E	X	X	X	X	C	*
Recycled Concrete	90	120	*	*	X	*	*	*	*	*	*	*
Sand	90	110	*	*	*	A	*	*	*	*	*	*
Scoria	light		E	*	*	E	*	E	*	*	E	X
Shell	60	115	*	*	*	*	*	*	*	*	*	*
Spent Bauxite	135=		D	E	X	D	D	D	X	X	*	*
Steel Slag	115=		*	*	*	*	*	E	*	*	*	*

* - Feasible Substitute
A - Feasible When Used in a Sand-Clay-Gravel Mixture
B - Feasible by Possibly Reducing the Amount of Shell Needed
C - Soluble - Stabilization and Dry Environment May be Required
D - More Information Needed - Would Have to be Stabilized
E - More Information Needed - May be a Feasible Alternative
X - Unacceptable
= - Little Variation in Bulk Density

2.2.2. **Renew Permits with Existing Conditions**

This alternative assumes USACE permits will be renewed as they currently exist under the restrictions detailed in Appendix B.

The removal of shell resources within the project area (Zones 1, 2, and 3) is currently allowed upon 167,300 of the total 239,500 acres. These restrictions deal largely with constraining the operations of the dredges within certain regions, in order to protect sensitive resources (i.e., the developing delta, exposed oyster reefs, etc). Dravo Basic Materials holds an exclusive lease on Zones 1, 2, and the eastern half of Zone 3. They share a lease with Lake Charles Dredging & Towing on the western half of Zone 3. (The latter company has not actively dredged shell since 1983.) Each of the two companies is permitted to operate two dredges.

2.2.3. **Renew Permits with Additional Restrictions**

This alternative assumes that shell dredging would continue under imposition of additional constraints. For purposes of this analysis, three major groups of increased restrictions to be examined are detailed below. The alternatives to be considered under this plan of action include additional areal restrictions, additional restrictions on dredging intensity, and restrictions on dredge discharge.

2.2.3.1. **Additional Restrictions on Areas Available for Dredging**

Over the years, numerous restrictions on areas available for dredging have evolved as a result of continued monitoring of the shell dredging industry. Some of these restrictions are intended to minimize impacts to the developing deltas at the Wax Lake Outlet and the mouth of the Atchafalaya River, and to protect exposed oyster reefs (live and fossil), pipelines, and prevent shoreline erosion. Additional areal restrictions to be considered in this document are as follows:

1) Closure of the bottom half of Four League Bay to shell dredging activities. Dredging would be restricted to areas north and west of a line from Mosquito Point to a point south of the mouth of Big Carencro Bayou (Figure 8). This line would partition the bay and may provide additional protection to the existing and developing oyster reefs in the southern half of Four League Bay. Impacts of this alternative will be considered in detail in this EIS.

2) Closure of all of Four League Bay to shell dredging operations. This would eliminate only about 8 percent of the currently permitted area from availability. Although this percentage is not large, closure of the region would permanently deny the industry of approximately 7 MCY of shell, the total proven reserves in Four League Bay. This figure represents roughly 28% of the total proven reserves in the coastal areas, a major portion of the volume of identified shell. In addition, this alternative would do nothing to protect the sensitive oyster reefs in the southern portions of portions of the bay that could not be accomplished by closure of only the bottom half of the bay. Therefore, this alternative will not be considered in further detail in this EIS.

3) Expansion of the protective zones arcund the developing deltas at the mouth of Wax Lake Outlet and Atchafalaya River. Current restrictions around this region provide a large boundary within which dredging of any type is prohibited (Figure 7). This large protective zone represents a compromise between agencies involved in regulation of the industry, representatives of the shell dredging industry, and personnel from agencies which play a major advisory role (U. S. Fish and Wildlife Service and National Marine Fisheries Service). Recommendations made in regard to this matter by the above-noted agencies have centered around the need to modify this zone in the event of a major flood through the Atchafalaya Basin. If this were to happen prior to the next permit renewal application, the limits of the boundaries would be reevaluated. This can be accomplished at any time as part of a permit review. However, because this buffer is presently considered adequate by the regulatory agencies involved and no specific recommendations were

received during the scoping process, this alternative will not be considered in further detail.

2.2.3.2. **Additional Restrictions on Dredging Intensity**

Restrictions dealing with the level of dredging intensity within the project area exist. The single constraint on each company is that it may operate a maximum of two dredges at any one time. This limitation means that in most of the area covered in this document, no more than two dredges can be operated. Dravo Basic Materials holds an exclusive lease in Four League Bay, Atchafalaya Bay, and the eastern half of East Cote Blanche Bay. The western half of this latter region is held under a joint lease by Dravo Basic Materials and Lake Charles Dredging and Towing Company. As the permits currently exist, a maximum of four dredges could operate in the area at any one time. An alternative to reduce dredging intensity in the western half of East Cote Blanche Bay from a maximum of four to two dredges will be carried through this EIS for greater analysis. However, within the other regions of the currently permitted areas where only two dredges can operate, no request for a reduction of dredging intensity surfaced from the regulatory agencies or the general public.

2.2.3.3. **Additional Restrictions on Dredge Discharge**

The LDWF has mandated that all discharge of the dredges must be directed back into the cut from which it was removed. In addition, the cut is surveyed and levelled to remove any potential navigation hazards. Additional suggestions during the scoping process were the reduction of discharge velocity and the reduction of turbidity due to dredging.

Concern over the velocity of discharge of the shell dredging operation is related to a perceived disturbance of the benthic community created by this discharge (Steimle and Associates, 1985). Discharge of the wash and associated materials which result from the operation of the shell dredge are not under pumped pressure. The material drops by

gravity flow into the waters behind the dredge, redirected back into the cut to the maximum extent practicable. Damage to the benthic animals has probably already occurred with the actual removal of organisms during the dredging process. The discharges do create disturbances in the water column, in addition to those created by the propeller wash. Several ways to reduce the velocity of the discharge before it re-enters the water have been investigated, including placement of a box or baffles beneath the discharge to dissipate the velocity. Although velocity was indeed reduced, other problems (e.g., clogging) arose which minimized the benefit of any of the techniques examined. An alternate method, submersal of the discharge pipe, appeared to have some merit. However, in shallow bay systems, this may cause even more disruption by a concentration of the discharge into a jet of water which may then scour the bay bottom.

A method to reduce turbidity, silt screens, has also been closely examined. These were shown to be very effective in minimizing turbidity resulting from dredging operations. However, they are most efficient when used in conjunction with stationary operations in areas of low current velocity. Unfortunately, this is often not the case in removal of shell from coastal areas of Louisiana. Although the dredges are slow and ponderous in their movements, they cover approximately 150 linear feet a day in areas where currents are occasionally very strong. Silt screens are not practicable and will not be considered in further detail.

2.2.4. **Renew Permits with Reduced Restrictions**

Analysis of impacts of shell dredging should also include an option for the reduction of restrictions imposed on the industry. This analysis should include an easing of the restrictions on the areas available for dredging, as well as a relaxation of constraints on the dredging intensity and methods of dredge discharge.

2.2.4.1. Increased Areas Available for Dredging

Shell dredging is currently allowed in 167,300 acres of the project area, with the remaining 72,200 acres placed under restrictions which prohibit shell dredging industry. These areal restrictions constrain dredging within a half mile of the shoreline, 1,000 feet of a subaqueous reef, 1,000 feet of an active oil or gas well platform, over pipelines, and within large protective zones surrounding developing deltas at the Wax Lake Outlet and the mouth of Atchafalaya River. Indications from regulatory agencies charged with monitoring the industry are that a reduction in areas available for dredging (increasing restricted zones) is not acceptable. Industry representatives have indicated interest in reducing the restrictive zone around the shoreline in the upper half of Four League Bay from 0.5 miles to 1,500 feet. This alternative will be examined and carried through the EIS for further analysis.

2.2.4.2. Increase Dredging Intensity

Regulations in place at this time allow dredging to take place over a 24 hour period per day and 365 days a year. An alternative to further reduce restrictions which may be limiting the productivity or efficiency of the industry would be allowance of additional dredges in conjunction with those already permitted. However, consultation with representatives of the shell dredging industry has shown this alternative to be impractical. Dravo Basic Materials and Lake Charles Dredging and Towing have expressed no desire at this time or within the foreseeable future to put additional dredges into operation. Any alternative that examines unrealistic options is not practical and will not be carried through the EIS for further analysis. Therefore, no additional alternatives that consider reduced restrictions on dredging intensity will be considered further.

2.2.4.3. **Reduced Restrictions on Dredge Discharge**

Current restrictions require bathymetric traces of each cut be made to show that no large deposits of material remain which may interfere with navigation and discharged material be directed back into the cut. These represent the minimum restrictions consistent with navigation requirements.

2.3. **ALTERNATIVES CONSIDERED IN DETAIL**

The following alternatives will be retained for detailed environmental, economic, and social consideration throughout this document. These alternatives have been assigned a number for ease of discussion, and are:

ALTERNATIVE 1- RENEW PERMITS WITH EXISTING CONDITIONS.

ALTERNATIVE 2- PERMIT DENIAL (NO ACTION).

ALTERNATIVE 3- RENEW PERMITS WITH EXISTING CONDITIONS, BUT CLOSE BOTTOM HALF OF FOUR LEAGUE BAY TO DREDGING ACTIVITIES (CLOSURE OF BOTTOM HALF OF FOUR LEAGUE BAY).

ALTERNATIVE 4- RENEW PERMITS WITH EXISTING CONDITIONS, BUT REDUCE WIDTH OF ZONE RESTRICTING DREDGING NEAR SHORE IN UPPER HALF OF FOUR LEAGUE BAY FROM 0.5 MILES TO 1500 FEET (REDUCE SHORELINE RESTRICTIONS IN UPPER FOUR LEAGUE BAY)

ALTERNATIVE 5- RENEW PERMITS WITH EXISTING CONDITIONS, BUT REDUCE DREDGING INTENSITY TO ALLOW A MAXIMUM OF TWO DREDGES IN WESTERN EAST COTE BLANCHE BAY (REDUCE DREDGING INTENSITY IN WESTERN EAST COTE BLANCHE BAY)

Alternatives 1, 3, 4, and 5 are within the capability of the applicant and within the jurisdiction of the Corps of Engineers. The Permit Denial (No Action) alternative falls under category of being beyond both the capability of the applicant and outside the jurisdiction of the Corps of Engineers. Permit denial is within the jurisdiction of the Corps; however, in this case, permit denial means that alternative material would be used as a substitute. The Corps would likely have no jurisdiction over the mining of limestone.

2.4. MITIGATION MEASURES

Mitigation measures are currently in place which require offsite compensation when recommended by the Secretary of the LDWF. The compensation consists of construction of a shell reef at a location recommended by LDWF and DNR. The reef shall be a minimum of one foot in thickness and not less than one acre in areal extent for each 200,000 cubic yards of shell removed from the permitted areas. These proposed reefs shall be built at the expense of the shell-dredging industry with the intention of improving the marine environment.

At this time, a single reef has been constructed by Radcliff Materials, Inc., (now DRAVO Basic Materials Corp.) and Lake Charles Dredging and Towing Company. The 0.92 acre reef was permitted in June 1978, and constructed as 400 feet in length and 100 feet in width. The fishing reef is located 0.5 miles northeast of Cypremort Point in West Cote Blanche Bay. Since that time, no additional offsite restoration measures have been imposed on the industry.

2.5. COMPARATIVE IMPACTS OF ALTERNATIVES

The following table presents a comparison of the impacts of each of the five alternatives considered in detail on each significant resource/issue.

3. EXISTING CONDITIONS AND IMPACTS OF ALTERNATIVES

3.1. INTRODUCTION

The purpose of this section is to assess all conditions as they currently exist and the impact of the previously identified alternatives.

As noted previously, duration of impacts within the East Cote Blanche/Atchafalaya/Four League Bay area is largely dependent on the volume of shell located within each bay. Proven reserves (6.2 MCY) within East Cote Blanche Bay would lead to a duration of impacts of about 2.1 years, while the estimated 5.875 MCY in Atchafalaya Bay would allow for 2 years of activity. Shell reserves in Four League Bay (under current distance constraints) have been estimated at 3.15 MCY. Thus, at current production rates, dredging is estimated to continue for the next 5 years. However, these figures are estimates, based on gross surveys, and the representatives of the shell dredging industry have stated the unproven reserves may be much larger.

Alternatives 3, 4, and 5 all basically include renewal of the permit with existing conditions, but then each alternative adds or deletes restrictions. Thus, some of the impacts of those alternatives are similar to Alternatve 1. The following discussion will focus on differences between Alternatives 3, 4, and 5.

3.2. LOCATION AND ENVIRONMENTAL SETTING OF PROPOSED ACTIVITY

The East Cote Blanche/Atchafalaya/Four League Bay estuarine system (Figure 2) covers approximately 40 linear miles of coastline within the

TABLE
COMPARATIVE IMPACTS OF ALTERNATIVES

RESOURCE/ISSUES	EXISTING CONDITIONS	RENEW W/EXISTING COND. Alternative 1	PERMIT DENIAL Alternative 2	CLOSE BOTTOM HALF OF FLB Alternative 3	REDUCE RESTRICT IN UPPER FLB Alternative 4	2 DREDGES IN WESTERN ECBB Alternative 5
MINERAL RESOURCES	Numerous producing oil and gas wells.	No impact.	No impact.	No impact.	No impact.	No impact.
PHYSICAL PROCESSES	Subsidence rates from 0.34 ft/100 yrs to 0.98 ft/100 yrs. Shoreline erosion averages 7-13 ft/yr in some areas, 31 ft/yr. Surface area of FLB increasing. Delta being developed in Atchafalaya Bay.	No impact on subsidence. Holes left by dredging would have negligible impact on wave heights, coastal erosion, and land loss. Shell removal would cause some delay in delta development.	No impact on subsidence, land loss, or the Atchafalaya Delta. Estimates of rate of delta development and filling of ECBB are the same with and without shell dredging.	Similar to Alt. 1, except no impacts in lower FLB.	Similar to Alt. 1. Reducing restriction should have negligible impacts on coastal erosion and no impact on subsidence, land loss, and delta development.	Similar to Alt. 1.
HOLES/TROUGHS	Holes and troughs in various stages of filling exist throughout project area where dredging has occurred.	In areas of high sedimentation, holes fill rapidly. Fill rate much slower in areas where scour is occurring.	Existing holes would all fill. No more would be produced.	Similar to Alt. 1. No holes dug in lower FLB.	Similar to Alt. 1. Fill rate of holes 1500 feet from shore would be equal to fill rate 2500 feet from shore.	Similar to Alt. 1. Fewer holes would be dug in western ECBB on an annual basis.
REFUGES/WMA's	Atchafalaya Delta WMA, 125,000 acres of shallow water, marsh, and ridge. Marsh Island Refuge, 82,000 acres of marsh.	Atchafalaya Delta WMA - no impact to delta. Minor impact to waterbodies. No impact to Marsh Island.	No impact	Similar to Alt. 1. No additional impacts.	Similar to Alt. 1. No additional impacts.	Similar to Alt. 1. No additional impacts.
WATER COLUMN WATER QUALITY/SEDIMENT QUALITY-CONTAMINANTS/ SEDIMENT-PHYSICAL CHARACTERISTICS	Designated for primary and secondary contact recreation and fish and wildlife propagation. Project area, except for FLB, designated for shellfish propagation. Total coliforms consistently exceed DEQ limits in FLB. Sediments generally silty clay to clayey silt. Natural turbidity levels high in winter and spring (55-110JTU). Natural bulk density averaged 1.5 at surface and 1.6 overall.	No significant impacts on water quality. Temporary increase in turbidity and suspended solids within a few hundred feet of dredge. Long term turbidity impacts inconsequential. No biomagnification impacts. Fluid mud impacts minimal and local. No significant release of contaminants from sediments. Much sediment settles back into holes.	No dredging-related turbidity. 500-600 acres of water bottoms would remain undisturbed each year.	Similar to Alt. 1, except no dredging-related impacts in lower FLB.	Similar to Alt. 1, but allows dredging over 600 additional acres.	Similar to Alt. 1.
PHYTOPLANKTON	Peaks at low river conditions. Greater phytoplankton productivity in waters of intermediate salinity.	Impacts minimal, highly localized and confined to an area of approximately 200 acres around each dredge where dissolved oxygen lowered and light penetration decreased. Thus, phytoplankton productivity lowered. Resuspension of nutrients may increase productivity.	Minor impacts to phytoplankton would cease.	Similar to Alt. 1 with no impact in lower FLB.	Similar to Alt. 1, but with slight reduction in phytoplankton productivity possible over 600 additional acres of upper FLB.	Similar to Alt. 1, but already minor impacts halved in western ECBB.

TABLE (Continued)
COMPARATIVE IMPACTS OF ALTERNATIVES

RESOURCE/ISSUES	EXISTING CONDITIONS	RENEW W/EXISTING COND. Alternative 1	PERMIT DENIAL Alternative 2	CLOSE BOTTOM HALF OF FLB Alternative 3	REDUCE RESTRICT IN UPPER FLB Alternative 4	2 DREDGES IN WESTERN ECBB Alternative 5
FISHERIES	Productive - typical of north central Gulf of Mexico estuary with a strong freshwater influence.	Impacts to fisheries transient and minimal. Temporary turbidity causes numerous minor impacts - clogs gills, affects behavior, or interferes with feeding. Holes left after dredging provide refuge for fish during cold weather.	Minor impacts to fisheries would cease.	Similar to Alt. 1, but with no impact in lower FLB.	Similar to Alt. 1, but duration of minor impacts to fisheries would be lengthened by 1 year.	Similar to Alt. 1, but already minor impacts halved in western ECBB.
BENTHOS	Productive - shifts from fresh to estuarine seasonally. Dominated by few, wide-spread species.	If all 4 permitted dredges operated, benthos on 5 acres of water bottoms would be destroyed each day. As holes fill, repopulation starts within 3 months and generally complete within 3 years. Fluid mud layer thin and only impacts small organisms or poor burrowers.	Minor impacts to benthos would cease.	Similar to Alt. 1, but no impact in lower FLB.	Similar to Alt. 1, but an additional 600 acres would be available for dredging.	Similar to Alt. 1, but already minor impacts halved in western ECBB.
OYSTER REEFS	Salinity in project area generally too low for oyster production. During high salinity years, temporary reefs occur. Freshwater and sediment generally destroy these within a year. Exposed reefs are highly productive centers of biological activity. Buried reefs have no biological, geological, or hydrological value.	1000 feet no-dredging buffer zone prevents impacts to emergent live or dead reefs.	Sedimentation and fresh water would continue to limit reef appearance.	Similar to Alt. 1.	Similar to Alt. 1.	Similar to Alt. 1.
ENDANGERED AND THREATENED SPECIES	Endangered Kemps ridley sea turtle and threatened loggerhead sea turtle sighted in project area.	Negligible impacts.	No impacts.	Similar to Alt. 1.	Similar to Alt. 1.	Similar to Alt. 1.

TABLE (Continued)
COMPARATIVE IMPACTS OF ALTERNATIVES

RESOURCE/ISSUES	EXISTING CONDITIONS	RENEW W/EXISTING COND. Alternative 1	PERMIT DENIAL Alternative 2	CLOSE BOTTOM HALF OF FLB Alternative 3	REDUCE RESTRICT IN UPPER FLB Alternative 4	2 DREDGES IN WESTERN ECBB Alternative 5
BUSINESS AND INDUSTRIAL ACTIVITY	Most shell used for general construction and maintenance. Production is declining, recently averaged just over 3 million cu. yds. per year valued at $28,500,000. With multiplier effect; actual benefit to economy on the order of $102,700,000 per year. Mineral production and fishing also important in project area.	Oyster shells would continue to provide material for construction for at least 5 years and probably much longer. If economy improves, 4 dredges could operate in western ECBB.	Shell lost as construction material. Alternative sources cost roughly 50% more. Loss of $13,230,000 in capitol investments.	Similar to Alt. 1, but life of industry slightly lengthened.	Similar to Alt. 1, but an estimated additional 2.5 million cy. yds. would be available.	Similar to Alt. 1, but life of industry slightly shortened.
EMPLOYMENT/LABOR FORCE AND DISPLACEMENT OF PEOPLE	Unemployment 19.5%. 160 jobs in project area due to shell dredging. 477 additional jobs depend on dredging.	Shell dredging jobs sustained until depletion of the resource.	Approximately 143 jobs lost directly. Some jobs dependent on dredging also lost. People forced to take lower paying jobs, leave or stay unemployed.	Similar to Alt. 1. Slightly adverse impact on future employment and displacement of people.	Similar to Alt. 1. Slightly positive impact in future-proven reserves would allow nearly an additional year of employment and forestall displacement for that period.	Similar to Alt. 1. Should economy improve future employment opportunities lost, possible future displacement of people.
PROPERTY VALUES	Values falling. Dredgers have $28 million in equipment.	Value of dredging equipment maintained until recoverable shell gone.	$15 million in equipment could be salvaged, $13 million lost. Unemployment cause loss in value of residential housing.	Similar to Alt. 1. Would preclude favorable impacts when these resources not available.	Similar to Alt. 1. Favorable impact when dredging occurs.	Would preclude any favorable impacts to property values if chances for 4 dredges ever arose.
PUBLIC FACILITIES AND SERVICES/TAX REVENUES	Most shell used as base for roads. LDWF collects royalties - $900,000 in 1985. $161,000 in severence taxes collected in 1985. Royalties and taxes benefit public services.	Public services continue to be enhanced by royalties and taxes and shells available for roads until resource depleted.	More costly, less desirable road base must be used. Loss of royalty and tax money would add to governmental budgetary deficit. Increased outlays for unemployment.	Similar to Alt. 1 until other shells depleted, then similar to Alt. 2.	Similar to Alt. 1, but impacts would last at least one year longer and additional $750,000 added to state revenue.	Similar to Alt. 1. Would preclude future production of shells and accompanying revenue (if economy improves).
TRANSPORTATION	Shell is best aggregate for use in highway and airport construction, especially in wetlands.	Shell would continue to be available for highway work until resources depleted.	Other aggregates would have to be used at greatly increased cost.	Similar to Alt. 1 until reserves needed, then similar to Alt. 2.	Similar to Alt. 1, but shell available for highway work for an additional year.	Similar to Alt.1, opportunities for future "road shells" precluded.
ESTHETIC VALUES/NOISE	Natural turbidity high in project area, especially during high river flows. Noise in bays from oil field operations and fishing.	Only esthetic and noise impacts are increased turbidity/noise in the immediate vicinity of the dredge.	No impact	Similar to Alt. 1, except no noise or turbidity impacts in lower FLB.	Similar to Alt. 1, but possibility of esthetically unpleasing turbidity being seen or noise being heard from shore.	Similar to Alt. 1 but would lessen possible future impacts in western ECBB.
ARCHEOLOGY/CULTURAL RESOURCES	Underwater cultural resources protected by existing regulations.	Same as existing conditions.	No impact	Same as existing conditions.	Same as existing conditions.	Same as existing conditions

TABLE (Continued)
COMPARATIVE IMPACTS OF ALTERNATIVES

RESOURCE/ISSUES	EXISTING CONDITIONS	RENEW W/EXISTING COND. Alternative 1	PERMIT DENIAL Alternative 2	CLOSE BOTTOM HALF OF FLB Alternative 3	REDUCE RESTRICT IN UPPER FLB Alternative 4	2 DREDGES IN WESTERN ECBB Alternative 5
DESIRABLE REGIONAL GROWTH/DESIRABLE COMMUNITY GROWTH/COMMUNITY COHESION	Growth slow in recent years; linked to factors such as stable employment and high income. Cohesion affected by concern about impacts on delta building and shoreline erosion.	Continued employment, royalties and taxes generated by industry until depletion would contribute to positive community and regional growth and community cohension.	Adverse impact; more costly, less desirable material would further discourage regional and community growth. Loss of employment also adversely affect growth and cohesion.	Similar to Alt. 1, but growth hampered when FLB reserves needed to sustain industry.	Similar to Alt. 1, growth and cohesion stimulated for one year once other reserves depleted.	Similar to Alt. 1, but opportunities for future growth and cohesion precluded.
RECREATION	Opportunities for variety of outdoor oriented recreation-fishing and shrimping very popular.	Little or no impact. Some fishermen would leave the vicinity of the dredge, others would congregate there in the belief that fish are attracted to the disturbance.	Little impact., any benefits of fish attracted to dredging would be lost.	Similar to Alt. 1, no dredging impacts in lower FLB.	Similar to Alt. 1.	Similar to Alt. 1.

Mississippi Deltaic Plain Region. This complex region is characterized by extensive coastal wetlands, shallow embayments, and high biological productivity.

Four League Bay is a shallow, bilobed system with a narrow mouth at the northern extremity opening into Atchafalaya Bay. The southern end of the bay exchanges water with the Gulf of Mexico through a constricted pass known as Oyster Bayou. To the north and west, Four League Bay is bounded by low marsh characteristic of the coastal regions of the state. Vegetation of these marshes is predominantly fresh and brackish by nature because of the influence of the Atchafalaya River. Approximately 20,500 acres of waterbottom are contained within its boundaries with an average depth of roughly 3 feet. Shell dredging is currently permitted within 14,100 acres (69%) of the bay, although recent activities have been concentrated within the northern sectors.

Atchafalaya Bay is a large, shallow system dominated by the formation of an accreting delta at the mouths of the Atchafalaya River and Wax Lake Outlet. The bay has an average depth of about 6 feet and is surrounded by almost completely fresh marshes because of the strong influence of the river. Approximately 127,000 acres are enclosed within the boundaries of the study area, with shell dredging permitted in roughly 75,700 acres of the area (60%). The other 40% is prohibited to shell dredging activities because of large protective zones which surround deltas, shorelines, and exposed (subaerial) oyster reefs. In recent years, shell dredging operations have concentrated in the southern and eastern sections of this area. However, operations are currently centered in the north-central section of the bay, between the protected areas around the deltas.

East Cote Blanche Bay is a shallow embayment bounded on the southeast by Atchafalaya Bay, on the northeast by fresh and intermediate marshes, on the northwest by West Cote Blanche Bay, and on the southwest by Marsh Island and the Gulf of Mexico. Average depths are four to six feet and are decreasing over time. Approximately 91,800 acres are enclosed within these boundaries, with shell dredging operations permitted within 77,500

acres (84%) of the area. The high inflow rates of the Wax Lake Outlet and the Atchafalaya River, and the generally westward drift of the suspended materials, give rise to high sedimentation rates. This sediment consists of finer silts and clays which are carried in suspension by tides, currents, and waves. Mudflats form periodically in low energy areas within the region and are continuously reworked by erosional forces. Shell dredging operations in the recent past have been concentrated in the southern and western portions of the bay.

Thompson's (1953) work on the geological oceanography of the Atchafalaya Bay region discusses many aspects of the physical processes that influence the bay system. That author presented figures on the effect of winds, waves, storms, and currents within the bay. However, parts of his presentation must now be used with caution or supplemented with other, more recent data. Many of the physical features of the bays (e.g., development of the deltas, removal of massive sections of the Point Au Fer Shell Reef, accretion of mudflats) have undergone dramatic changes from the time of his work. However, Thompson's (1953) overview of many of the processes is still valid.

3.3. GEOMORPHIC HISTORY OF THE AREA

3.3.1. Introduction

The project area is located within the Gulf Coast Plain physiographic province. This province is a region of low relief and represents a vast sedimentary basin which extends from Florida to Texas, and continues beneath the Gulf of Mexico forming the continental shelf. Exposed sediments, deposited in both marine and fluvial environments, generally dip gulfward at rates varying between one to five feet per mile at the surface, to 50 feet per mile in the subsurface. The oldest sediments deposited in the Gulf Coastal Plain are Cretaceous in age; however, surface deposits exposed within the immediate study area are Holocene in age. The present geomorphic features in the area owe their configuration

to the combined effects of alluvial sedimentation, subsidence, and erosion within the last five to six thousand years.

3.4. PHYSICAL ENVIRONMENT

3.4.1. Geological Resources

3.4.1.1. Mineral Resources

3.4.1.1.1. Existing Conditions

Current mineral resources found in the study area, in addition to shell, consist primarily of oil and gas. East Cote Blanche Bay contains numerous producing wells centered in the northwest and southern sections of the bay in Iberia and St. Mary Parishes. Numerous wells and producing fields are scattered throughout Atchafalaya Bay in St. Mary and Terrebonne Parishes. Four League Bay has several concentrations of wells located primarily in the north, northwest, and southeastern sections of the bay in Terrebonne Parish. Impacts of the various alternatives on oil and gas resources are given below.

3.4.1.1.2. Impacts of Alternatives

ALTERNATIVE 1- Renew Permits with Existing Conditions

This alternative would have no impact upon existing mineral production since existing permitting restrictions incorporate the necessary distance restraints to insure safe operations.

ALTERNATIVE 2- Permit Denial (No Action)

This alternative would have no impact on existing mineral production.

ALTERNATIVE 3- Closure of the Bottom Half Of Four League Bay

Same as Alternative 1.

ALTERNATIVE 4- Reduce Shoreline Restrictions in Upper Four League Bay

Same as Alternative 1.

ALTERNATIVE 5- Reduce Dredging Intensity in Western East Cote Blanche Bay

Same as Alternative 1.

3.4.1.2. Physical Processes

3.4.1.2.1. Existing Conditions

Physical processes affecting the project area are complex and highly inter-related. Some of the dominant physical processes most likely to be impacted here are subsidence, land loss resulting primarily from coastal erosion, and the development of the Atchafalaya Bay delta. Details on these processes have been incorporated within Appendix C.

3.4.1.2.2 Impacts of Alternatives

Alternative 1- Renew Permits with Existing Conditions

Subsidence - Vibracore borings taken by the USACE in several dredged areas and in immediately adjacent, undredged areas, indicate no significant difference between the soil parameters and characteristics of material within the dredged and refilled areas, and the undisturbed material located outside dredged areas. Therefore, subsidence will continue at the same rate in the study area, regardless of the presence or absence of shell dredging activities. Only outside influences, such as increased sedimentation, erosion, and local uplifting, will have any effect on subsidence in the study area.

Land Loss - A deeply dredged hole close to shore can cause refraction of waves so as to concentrate wave energy on a particular segment of shoreline, thereby accelerating erosion if the fetch is long enough for wave generation. Most holes that exist are 350 to 800 feet across and a maximum of 3-4 feet deep from the bottom surface. Such a hole 2,500 feet from shore will not directly cause coastal erosion. It might cause a slight decrease in wave height for waves generated outside of the general area and a slight increase in height for waves generated within the area. Overall impacts of such a hole on average wave heights and storm surge heights, including hurricanes, would be negligible.

Four League Bay is more constricted than Atchafalaya Bay and East Cote Blanche Bay. If enough holes are dredged in Four League Bay that the average bottom depth is lowered and the volume is increased, the tidal prism will increase, thereby increasing the cross-sectional area of the mouth of the bay to accommodate it. The increased tidal velocities will aid in scouring the tidal entrance. Dredging too close to the shore, within about 200 feet, will cause the immediate offshore slope to become unstable. This will cause erosion along the shoreline when the slope slumps into the dredge hole. The 2,500 foot offshore restriction for the upper half of Four League Bay will keep dredging a sufficient distance from the shoreline to prevent significant impact on the shoreline.

Atchafalaya Bay Delta - Shell dredging is not allowed in the sub-aerial portion of the delta and portions of the subaqueous delta. Shell dredging is allowed in the prodelta and portions of the subaqueous delta. The net effect of shell dredging will be some delay in delta development in and around the dredge cuts as the holes and troughs fill with sediments. The holes left by the passage of the shell dredge may act as sediment traps, diverting sediment that might otherwise have been used in building prodelta. These impacts are more likely in areas along the flanks of the deltaic landmasses where riverine and tidal processes combine to scour the bay bottom. The area between the mouth of Four League Bay and Point au Fer is particularly affected, as well as the

seaward portion of the Atchafalaya Bay between the two delta lobes. The strict observance of the present -2 ft NGVD contour restriction (included within the protective zones surrounding the deltas) should minimize the loss of delta. In terms of volume, the amount of material necessary to replace the annual quantity of shell removed is approximately 6 percent of the annual silt and clay load of the Atchafalaya Basin Floodway system as measured at Simmesport. The amount of shell removed should not have any significant effect on delta development other than some delay in development in the area of the dredge cuts.

Alternative 2 - Permit Denial (no action)

Subsidence - Permit denial would have no impact on subsidence in the project area since present subsidence is independent of any dredging that is occurring.

Land Loss - No impact.

Atchafalaya Bay Delta - Volumetric estimates for the growth of the delta would remain the same and no significant impact would be evident.

Alternative 3 - Closure of the Bottom Half of Four League Bay

Subsidence - No impact.

Land Loss - No impact.

Atchafalaya Bay Delta - No impact.

Alternative 4 - Reduce Shoreline Restrictions in Upper Four League Bay

Subsidence - No impact.

Land Loss - Dredge holes 3-4 feet deep and 350-800 feet across should not directly cause coastal erosion when dredged 1,500 feet from the shore-

line. It might cause a slight decrease in wave height for waves generated outside the area and a slight increase in height for waves generated within the area. Overall impacts on waves heights are negligible. The 1,500 feet restriction for the upper half of Four League Bay should keep dredging a sufficient distance from the shoreline so that impacts on the shoreline are not significant.

Atchafalaya Bay Delta. - No impact.

Alternative 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Subsidence - No impact.

Land Loss - No impact.

Atchafalaya Bay Delta - No impact.

3.4.1.3. **Holes/Troughs from Shell Dredging**

3.4.1.3.1. **Existing Conditions**

The removal of buried reef shell is accomplished through the displacement of an overburden of mud (which may be considerable) before contact is made with the shell material. This process results in irregularly-shaped holes and troughs with a freshly-dredged bottom several feet below the surrounding seafloor. These holes and troughs have been identified as a significant issue during the scoping process. The depth of the trough is highly variable, depending on the amount of overburden removed, depth of the reef shell, location of the cut, river flows, hydrologic variables, and so on. No precise estimate of the refill rate is possible because of these variables. However, some information is available.

The effect of the refilling of the holes/troughs resulting from the shell dredging activities from a settlement/consolidation standpoint would be negligible as indicated by the borings, samples, and test results made at several past and current shell dredging locations. The borings made in areas where current shell dredging operations are active, indicate little difference between the geotechnical strength and consolidation parameters of material which is returned to the dredge cut within 8 to 10 hours, and the undisturbed material immediately adjacent to the cut. In addition, the immediate return of the unused/unsuitable dredged material to the cut may increase the compressive strength of the material. In one of the other two areas where shell dredging has actually occurred (southwest of the emerging Atchafalaya Delta); the borings, samples, and testing indicate that there is essentially no difference between the geotechnical parameters of the material that has returned to the dredge cut since 1978, and the undisturbed material immediately adjacent to the cut. This holds true to depths of 11 to 13 feet which was generally the original dredge cut depth. In areas located south-southeast of the emerging Atchafalaya Delta, the data indicate a very slight difference between the strength parameters of the refilled cut material and the undisturbed material on the north side of the dredge cut, but no difference from the undisturbed material from the south side of the dredge cut. While there is a small difference in the strength values (from vSo to So) between these two areas, the material found in the undisturbed area on the north of the dredge cut contains significantly more silty material which can increase the apparent strength of material in this low strength range.

Additional information pertaining to the studies performed and information regarding the refilling rates of dredged holes is available in Appendix C.

3.4.1.3.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

The rate of fill of dredge cuts is dependent on where shell dredging takes place. In the southwestern portion of the Atchafalaya Bay, the rate of fill should be similar to the rate for dredge cuts made in that area in 1977 and 1978. In the area between the deltas, the rate of fill will be dependent on the development of the deltas. There is a possibility that the rate of fill will be slower than the southwest portion of the bay because of the chance for scour channels to develop between the two deltas. In the east/southeast portion of the Atchafalaya Bay, the rate of fill will vary as it has in the past. Dredge cuts in the tidal exchange paths should exhibit the same characteristics as the dredge cuts made in 1980-81. The rest of the east/southeast portion of the Atchafalaya Bay and Four League Bay should be similar to those observed in 1980, 1982, and 1984, although the present observed trend of reduced sediment entering this area may decrease the rate of fill.

There are no historic data on rates of fill of dredge cuts in East Cote Blanche Bay. It is probable that cuts in this area would fill at a rate similar to cuts made in the southwest portion of Atchafalaya Bay.

This alternative would have no impact on the speed of refilling, source of material for refilling, or affect the strength parameters of the refilled areas.

ALTERNATIVE 2 - Permit Denial (No Action)

The dredge cuts already made will continue to fill at rates dependent on the riverine and coastal processes in the area of the cuts. It is postulated that in some areas the bathymetry of the cut will always lag behind the bathymetry of the surrounding undredged area until such time as the riverine processes dominate and subaerial land is developed.

Implementation of this alternative would have the effect of not creating holes/troughs in the study area. There is no evidence to suggest any detrimental effect upon the filling rate, subsidence rate, or enlarging rate in the project area as a result of the current shell dredging processes. No evidence suggests that the current shell dredging activities are "diverting" sediments from the emerging Atchafalaya Delta.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Closure of the bottom half of Four League Bay to dredging activities will prevent holes and troughs from appearing in that portion of the bay.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The rate of fill of dredge cuts 1,500 feet from shore should be similar to the rate for dredge cuts 2,500 feet from shore and would have no impact upon the holes/troughs *per se*. From a geological viewpoint, however, such a reduction in restrictions may effect shoreline changes since the potential for destabilizing the shoreline by the temporary creation of holes/troughs may be created. However, current data indicates rapid refilling and return to predredging conditions.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Reduction of dredging intensity in the western part of East Cote Blanche Bay will result in less holes and troughs in this area on an annual basis.

3.4.1.4. Refuges and Wildlife Management Areas

3.4.1.4.1. Existing Conditions

Two regions of special concern are located within the project area, the Atchafalaya Delta Wildlife Management Area and the Marsh Island

Wildlife Refuge, sometimes known as the Russell B. Sage Wildlife Refuge. The program is overseen by the Louisiana Department of Wildlife and Fisheries.

The Atchafalaya Delta Wildlife Management Area covers 125,000 acres at the mouth of the Atchafalaya River. The boundaries extend along a line due south of Point Chevreuil, and covers, to the east, all of Atchafalaya Bay. Hunting in the region is limited to waterfowl, which are locally abundant in the winter months. Other game species within the WMA include rail, snipe, and gallinule. Access to the region is limited to boat, with launches located near Morgan City, Berwick, and north of Highway 90 on the east levee of the Wax Lake Outlet.

The Marsh Island Wildlife Refuge contains 82,000 acres of generally low-lying marsh. Hunting and fishing are prohibited on the refuge and the LDWF maintains a staff on the island to enforce the fishing and hunting prohibitions. The region is heavily utilized by waterfowl, alligators, raccoon, muskrat, and mink. Deer are occasionally seen, and the shallow bays and sloughs serve as an important nursery area for many species of estuarine-dependant organisms.

Dredges are not allowed to operate within the Atchafalaya Delta Wildlife Management Area without "specific approval" by the LDWF. The granting of leases within the Management Area for the removal of shell resources by the appropriate state agencies does constitute "specific approval."

3.4.1.4.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renewal of Permits with Existing Conditions

Implementation of this alternative would mean no impacts to the Marsh Island Wildlife Refuge, since coastal erosion has been shown not to be a problem. Likewise, this alternative would have no impacts on the developing delta. Impacts to the waterbodies of the Atchafalaya Delta Wildlife Management Area are discussed elsewhere in this document.

ALTERNATIVE 2 - Permit Denial (No Action)

If Alternative 2 were selected as the course of action, any and all impacts to the special areas detailed above would cease.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Implementation of this alternative would have no impacts on either of the regions noted above.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

Same as Alternative 3.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Same as Alternative 3.

3.4.2. **Hydrological Resources and Water Quality**

3.4.2.1. **Introduction**

The water quality of a waterbody may have an impact on the organisms which live within or are dependent on the aquatic resources of a region. Inherent physical characteristics of the water (i.e., pH levels, etc.) and the manner in which it is affected by material which is carried in solution (i.e., salinity, suspended materials, heavy metals, etc.).

3.4.2.2. **Water and Sediment Quality**

3.4.2.2.1. **Existing Conditions**

The water column water quality of the project area is highly dependent on the flow of the major rivers and the effects of the adjacent Gulf

of Mexico. Detailed background information on the region is summarized in Appendix C.

Table 2 presents sediment quality data from five core samples taken from Atchafalaya Bay in 1976. Table 3 presents information obtained from elutriate tests on those samples. Additional information is presented in Appendix C.

3.4.2.2.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renew Permits with Existing Conditions

A major concern is that shell dredging releases contaminants from the resuspended sediments to the water column.

The data indicate that shell dredging in the permitted area will not contribute any significant concentrations of the constituents of concern to the surface waters. The constituents exceeding the criteria in the standard elutriate had already exceeded the criteria in the native water samples.

Examination of the sediment and elutriate data indicates that the material to be dredged is not contaminated. Dredging does not significantly degrade water quality. The temporary release of contaminants into the water column does not significantly increase contaminant concentrations, especially if mixing with the surrounding water is considered.

The primary effect of shell dredging on water quality is a temporary increase in turbidity and suspended solids levels. Concentrations of nutrients, such as nitrogen and phosphorus, could be temporarily elevated in the immediate vicinity of the dredging activity. This increase would be short-lived and is not considered significant in relation to the size of the area involved.

TABLE 2

ATCHAFALAYA BAY WATER QUALITY DATA-BOTTOM SEDIMENT

LOCATION	15	16	17	18	19
SAMPLING DATE	761015	761015	761015	761015	761015
NITROGEN, TOT KJD AS N (MG/KG)	2900	320	790	790	120
COD, (MG/KG)	6	2	4	3	1
CYANIDIE, (UG/G)	0	0	0	0	0
RESIDUE LOST ON IGNITION, (MG/KG)	42200	12800	28800	31800	4400
OIL AND GREASE, (MG/KG)	3000	0	3200	0	8100
ARSENIC, (UG/G)	11	6	8	7	2
CADMIUM, (UG/G)	<10	<10	<10	<10	<10
CHROMIUM, (UG/G)	<10	<10	10	10	10
COPPER, (UG/G)	15	<10	10	13	<10
LEAD, (UG/G)	<10	<10	<10	<10	<10
MERCURY, (UG/G)	0.05	0.02	0.05	0.02	0.00
NICKEL, (UG/G)	<10	<10	<10	<10	<10
ZINC, (UG/G)	50	25	40	40	20
ALDRIN, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
CHLORDANE, TOTAL (UG/KG)	0	0	0	0	0
DDD, TOTAL (UG/KG)	0.0	3.4	4.4	5.8	0.0
DDE, TOTAL (UG/KG)	0.0	0.0	2.3	3.6	0.0
DDT, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
DIAZINON, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
DIELDRIN, TOTAL (UG/KG)	0.0	0.2	0.6	0.5	0.0
ENDRIN, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETH PARTH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETH TRITH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETHION, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
HEPT. EPOX, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
HEPTACHLOR, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
LINDANE, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MALATHION, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MET, PARTH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MET, TRITH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
PCB, TOTAL (UG/KG)	0	0	0	0	0
PCN, TOTAL (UG/KG)	0	0	0	0	0
TOXAPHENE, TOTAL (UG/KG)	0	0	0	0	0

TABLE 3 ATCHAFALAYA BAY WATER QUALITY DATA-STANDARD ELUTRIATE

	SITE NUMBER				
LOCATION	15	16	17	18	19
SAMPLING DATE	10/15/76	10/15/76	10/15/76	10/15/76	10/15/76
NITROGEN, DISS. KJD (MG/L)	9.7	2.0	0.65	1.7	1.3
CHEMICAL OXY DEMAND (MG/L) (FILT. SAMPLE)	52	46	42	42	39
CYANIDE (MG/L)	0.01	0.00	0.00	0.00	0.00
PHENOLS (UG/L)	2	6	13	1	2
ARSENIC, DISSOLVED (UG/L)	4	1	1	2	1
CADMIUM, DISSOLVED (UG/L)	0	0	0	0	0
CHROMIUM, DISSOLVED (UG/L)	8	0	0	8	0
COPPER, DISSOLVED (UG/L)	2	3	3	2	4
LEAD, DISSOLVED (UG/L)	0	0	3	0	2
MERCURY, DISSOLVED (UG/L)	0.3	0.1	0.1	0.2	0.0
NICKEL, DISSOLVED (UG/L)	2	3	3	3	8
ZINC, DISSOLVED (UG/L)	10	10	20	10	10

In summary, the impacts of shell dredging operations on water column water quality are temporary and localized. Sediment data dealing with toxicity and bioconcentration of contaminants indicate that the open-water disposal of the sediments would not affect the quality of the water beyond the resuspension of material.

ALTERNATIVE 2 - Permit Denial (No Action)

With the shell dredges not operating, there would be less disturbance of the bottom sediments in the areas where shell dredging now takes place.

Turbidity may be slightly different than with Alternative 1.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Implementation of this alternative would have no water quality impacts significantly different from those of Alternative 1.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

Implementation of this alternative would have impacts on the water quality approximately the same as those of Alternative 1.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

This alternative would have no water quality impacts that would be approximately the same as those impacts associated with Alternative 1.

3.4.2.3. Sediment - Physical Characteristics

3.4.2.3.1. Existing Conditions

The types of sedimentary environments within the Atchafalaya Bay vary from bay bottom to marine to prodelta in the areas west, southwest, and south-southeast of the emerging Atchafalaya Delta; to active delta and delta front in the areas immediately adjacent to the subaerial and emerging Atchafalaya Delta on the west, south, and east. Generally, the bay bottom, marine, and prodelta sediments consist of very soft to soft clays with varying amounts of silt, sandy silt, shell and shell fragments, and organic material. The active delta and delta front materials consist generally of soft clays and silts with varying amounts of sandy silts, and small amounts of shell fragments; all of which exhibit varying amounts of oxidation. More detailed information on sediment characteristics is presented in Appendix C.

3.4.2.3.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

If shell dredging were to continue in the Bays area as currently permitted, the nature of future short- and long-term sediment-related physical impacts would be expected to continue as in the past. Rates of infilling of dredged cuts and reconsolidation of deposited sediments would be affected by chance occurrences of naturally variable and intermittent hydrologic events, including headwater floods and tropical storms. Turbidity levels would be considerably elevated at and near the dredging sites during dredging, but within a few hundred feet near-surface turbidity would return to near-background levels.

The shape and size of the turbidity plume are controlled by currents and turbulence in the water column. The plume proceeds in the general direction of the prevailing currents, and slowly descends through the

water column. The shallow water depths in the permitted area control to some degree the distance of travel of the plume. Within about 500 feet of an operating dredge, near-surface turbidity levels are typically reduced to about 1000 NTU or less, and suspended solids concentrations become reduced to about 2000 mg/L or less. The actual maximum turbidity levels that are generated depend primarily on the discharge slurry solids concentration, discharge pipe configuration, particle size distribution, water column turbulence and currents, and sediment organic content. Maximum turbidity levels within the plume tend to dimnish exponentially with distance from the dredge, and occur gradually lower in the water column with distance as gravity settling continues.

All but minor portion of the discharged solids are returned to the dredged cut and remain there as a soft, fluid mass that moves in response to gravity and bottom currents. Consolidation occurs with time, initially in the lower, most dense layers, and then sequentially in the upper layers. Bottom sediments from outlying areas are moved by natural circulation processes to gradually fill the dredged holes, requiring up to several years, particularly in zones of slower circulation. The discharged sediments that settle outside of the dredged area behave initially as fluid mud, and continue to flow laterally until their density and fractional forces prevent further movement by bottom currents. The new material soon becomes incorporated with the original material, and is no longer identifiable as a separate soil mass.

Since the major portion of the discharged solids is returned to the dredged cuts, the physical impacts of shell dredging on bottom conditions are likewise primarily limited to the area occupied by the cuts and the access trenches to the dredging sites. This amounts to a very small percentage (0.3%) of the total area permitted for dredging. Although the nature of the dredging activity and the subsequent processes of infilling and reconsolidation result in continuing significant physical impacts upon the dredge area itself, adjacent water bottoms are affected comparatively little by the activity. Discharged slurry solids that are deposited outside the dredged area flow in response to gravity and bottom

currents until they become sufficiently dense to remain in place and begin consolidation. The thickness of these layers of new material in surrounding areas cannot be reliably estimated without extensive field and laboratory measurements, and analyses, but would not be large enough to significantly change the physical nature of those water bottoms. From a geological standpoint, this alternative would have no impact on the physical nature of the sediments of the region.

In summary, it has been generally concluded by many investigators that localized high turbidity levels from operating dredges in large open water areas do not produce unacceptable long term impacts in the well mixed water column. The dramatically higher turbidity levels associated with the operation of the dredge are temporary and highly localized. Studies have shown that in excess of 95% of the resuspended material from dredging settles out of the water column within the first 200 feet. The remaining, finer-grained material may remain suspended longer and travel away from the discharge point, depending largely on the environmental conditions at the time and point of disposal. The turbidity generated by the operation of the shell dredges affects only a small percentage of the permitted area at any one time (a maximum of less than 1.5% of the waterbodies), and, so probably has no contribution to long-term turbidity increases. Thus, the effect of shell dredging on turbidity and water quality, when viewed in perspective of the large waterbodies in which it is permitted, and the naturally variable system, appears to be insignificant.

ALTERNATIVE 2 - No Action (Permit Denial)

The total restriction of shell dredging in the project area would eliminate the abnormally high turbidity and suspended sediment levels that characteristically occur in the immediate vicinity of an operating dredge. However, naturally high turbidity levels resulting from fresh water inflow would remain. In view of the very small proportion of the total area that is affected by shell dredging each year, and the naturally occurring turbidity-generating processes, it is concluded that

any such residual turbidity would be insignificant in comparison to the background levels.

The absence of shell dredging for an extended period of time would allow the formerly dredged cuts and access trenches to fill in to approximately the same elevations as the surrounding areas. If shell dredging operations were to be suspended, each year approximately 500 to 600 acres of water bottoms would remain undisturbed.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

The indirect effects of turbidity plumes and fluid mud extending from dredging sites in northern Four League Bay should be minimal. From a geological standpoint, this alternative would have no impact on the physical nature of the sediments.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The relative effect of this zone reduction on the total impacts that would occur would be slight, since the additional area involved is quite small compared to the currently permitted area. From a geological standpoint, this alternative would have no impact on the physical nature of the sediments.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Only two dredges have operated in western East Cote Blanche Bay since Lake Charles Dredging and Towing ceased shell dredging operations in 1983. Implementation of this alternative would continue a practice which has already been in effect for several years in the subject area. If implemented, it would ensure more balanced dredging intensity throughout the permitted areas, and would assure the western portion of East Cote Blanche Bay a level of physical impacts from dredging generally no greater than in other areas open to shell dredging, other factors being

equal. From a geological view point, this alternative would have no impact on the physical nature of the sediments.

3.5. BIOLOGICAL ENVIRONMENT

3.5.1. Botanical Resources

3.5.1.1 Introduction

Extensive growths of bulltongue (Sagittaria latifolia) and other marsh plants are present within areas of the developing deltas. These marshes are ephemeral and subject to deterioration due to scour or accretion. The most extensive grassbeds are within the protected zone of the delta. Another area of grassbeds is also on the protected northern edge of Point Chevreuil. These beds are composed primarily of submerged aquatic plants and are also within the protected 0.5 mile buffer zone surrounding the shoreline. Since all grassbeds are in areas prohibited to dredging, only the phytoplankton of the region is considered in detail in this section.

The botanical resources of the project area which are likely to be impacted by shell dredging are limited to phytoplankton and grassbeds. Grassbeds are severely limited in size and diversity in the project area. The reasons for this are diverse, and probably can be attributed to the dynamic hydrologic features of the region, salinity regimes, naturally high turbidity levels, and poorly consolidated sediments for growth of attached macroscopic flora.

3.5.1.2. Phytoplankton

3.5.1.2.1. Existing Conditions

Knowledge of the phytoplankton of the Project Area is derived from the works of two authors; Theriot (1976) and Randall (1986). Theriot has shown the phytoplankters of the region to be composed primarily of

centric diatoms, with peak abundance recorded in August, and lesser peaks in October-November, and in May-June. Randall has indicated that the primary productivity estimates are high compared to figures reported by other authors. That worker suggested the high primary productivity may be a function of the shallowness of the bay system. Additional information can be found in Appendix D.

3.5.1.2.2. <u>Impacts of Alternatives</u>

<u>ALTERNATIVE 1</u> - Renew Permits with Existing Conditions

Renewal of the current permits would allow for the continuation of any impacts, regardless of the magnitude, which are attributable to shell dredging. Impacts of shell dredging on phytoplankton center around the production of turbidity and the resultant decreased primary productivity. However, the area impacted by the increased turbidity, as shown in Appendix C, is relatively small.

In summary, the impacts of shell dredging operations on the phytoplankton community, and thus primary productivity, are highly localized. This impact may take the form of lowering dissolved oxygen levels, decreasing light penetration, increasing settling rates of phytoplankters, and altering water temperatures in the immediate area. However, the resuspension of nutrients may also stimulate phytoplankton productivity. It should also be remembered that shell dredging operations are not the only source of suspended materials and that naturally high turbidities are commonplace in the Four League/ Atchafalaya/ East Cote Blanche Bay system. These high turbidity levels are the result of high freshwater inflow from the rivers, wind-, wave- and storm-generated turbidities, natural erosion of the land, and resuspension of the fine sediments of the region. At any one time, the maximum permitted number of dredges would impact a small percentage of the waterbodies (from 0.2 to 1.6%). When placed in this perspective, the turbidity and associated impacts generated by the shell removal are minor.

ALTERNATIVE 2 - Permit Denial (No Action)

Implementation of this alternative would terminate the impacts, regardless of the magnitude, of turbidity generated by shell dredging on the phytoplankton of the region. Naturally high turbidity levels would remain as freshwater continues to dominate the hydrological characteristics of the bays. The trends noted by Theriot (1976) and Randall (1986) (e.g., low productivity during high-flow years, increased productivity with increased water clarity, decreased productivity with high salinity waters) would continue.

ALTERNATIVE 3 - Closure of the Bottom of Four League Bay

Primary productivity values in the bottom half of Four League Bay have been shown to be high, relative to values from adjacent waterbodies. Implementation of Alternative 3 would insure minimal disruption of the system by dredge-generated turbidity.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in the Upper Four League Bay

Same as Alternative 1.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

The abundance of phytoplankton in the western half of East Cote Blanche Bay has been shown by Theriot (1976) to be low, primarily due to the dominating influence of the Atchafalaya River and the Wax Lake Outlet. The region is naturally very turbid with diminished primary productivity. The reason for allowing a maximum of two dredges to operate in the region would be in an attempt to equalize the impacts of dredge-generated turbidity on the phytoplankton community of the region. As noted previously, the bulk of the suspended material generated by the dredges settle out within 500 feet of the dredge. However, under certain

conditions, this distance may increase. The use of 1,500 feet as the distance for resuspension, and the assumption that it is equally spread in all directions, leads to a total of 650 acres (4 dredges X 162 acres each) of water impacted. This figure is in excess of dredge-generated plumes that have been documented in the past.

East Cote Blanche Bay has approximately 91,800 acres of surface area, with shell dredging permitted in 84% of this area. Use of the 650 acres impacted by turbidity plumes leads to the conclusion that a potential maximum of only 0.7% of the total water mass would be impacted by 4 dredges. In recent years, one of the dredging companies with a lease to operate has not removed shell, and its 2 dredges have been inactive since 1983. Major positive changes in economic factors must happen before this company will reactivate dredges. Thus, the reality is that, within the reasonably forseeable future, a maximum of only 2 dredges would probably operate in the region at any one time. Turbidity associated with these 2 dredges only impact 0.35% of the water mass, an insignificant impact.

3.5.2. **Zoological Resources**

The zoological resources of the East Cote Blanche/Atchafalaya/Four League Bay system are tied to continually changing environmental parameters. The substrate and dominant physical characteristics of the bay system, and thus the zoological and botanical elements, are influenced by a number of factors. Among the most important of these are the freshwater inflow of the rivers, the passage of cold fronts with the associated northerly winds, salt-water intrusion, rapid temperature changes due to the shallowness of the bay system, high natural turbidity, and rapid sedimentation rates. These factors present the benthic and nektonic organisms with a highly dynamic and variable environment. The physical changes to which the estuaries are subject may be as slow as the alteration of salinity regimes with the seasons' change, or may be as rapid as the onset of a cold front. These fronts are most often associated with strong northerly winds that push large amounts of water

out of the bays, exposing broad mud flats and some of the oyster reefswhich protrude above the mud/water interface.

3.5.2.1. **Fisheries**

3.5.2.2.1. **Existing Conditions**

Fishery resources within the project area are those typical of the north-central Gulf of Mexico with at least 108 species of finfish recorded by several authors. The region is very productive in terms of fisheries resources and is projected to be of increasing importance with the development of the Atchafalaya Delta region (Thompson and Deegan, 1980). Although several works have been prepared which dealt with the fishery resources of the adjacent water bodies, few have dealt specifically with the East Cote Blanche/Atchafalaya/Four League Bay system. These works have been summarized in Appendix D.

3.5.2.2.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renew Permit with Existing Conditions

Impacts to fisheries are transient and minimal. As detailed in Appendix D, the temporary turbidity caused by dredging causes several minor impacts to fish. Spawning areas may be silted in, reducing developmental and hatching success. Turbidity may reduce the efficiency of visual feeders. Natural movements, behavior and migration may be affected. Gill tissue can become clogged with suspended sediments. Prolonged exposure to high turbidity may adversely affect growth. However, the project area aquatic organisms are adapted to a highly turbid environment and the turbidity engendered by shell dredging is temporary and localized. Thus, it has no significant effect on the fishery resources. There is no indication that the fishery resources of the project area have been or will be damaged or adversely affected in any way by the operations of the shell dredges.

Holes and troughs which result from shell dredging may provide an area of temporary refuge to fish during passage of cold fronts.

ALTERNATIVE 2- Permit Denial (No Action)

If existing permits are denied, then any detrimental or beneficial impacts attributable to the operation of shell dredges on the fishery resources of the region will cease. The localized and temporary turbidity levels associated with the removal of the buried oyster reefs will no longer be evident. However, the naturally high turbidity levels due to the inflow of the Atchafalaya River and the Wax Lake Outlet would continue and would not lessen due to the absence of shell dredging. The holes or trenches which result from the removal of shell would no longer provide a place of refuge for the resident fish populations during the passage of cold fronts. Any potential beneficial effects due to the resuspension of nutrients would be eliminated.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

If the lower one-half of Four League Bay were closed to the removal of shell, there would be no impact on the fishery resources of that region. No dredging has occurred in the area of the lower half of Four League Bay in many years.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The reduction of the size of the buffer zone in the upper half of Four League Bay only would have little impact on the fishery resources of the region beyond those detailed in Alternative 1. A greater percentage of the bay would be available to the dredges, and the duration of any impacts would be lengthened by approximately 1 year.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Impacts associated with this alternative are the same as those listed above under Alternative 1. Impacted regions would be reduced by half of the maximum potential impacts currently permitted.

3.5.2.2. **Benthos**

3.5.2.2.1. **Existing Conditions**

Knowledge of the benthic organisms within the East Cote Blanche/Atchafalaya/Four League Bay system comes primarily from the works of Hoese (1974), Dugas (1976; 1978), and the environmental study of GSRI (1977). A great amount of work has been conducted within other estuarine systems and adjacent waterbodies of the northern Gulf of Mexico and, with certain precautions, some of these data can be applied to the study areas. However, the unique attributes of this system make direct comparisons hazardous. The developing deltas, strongly fluctuating riverine input, high sedimentation rates, and subsidence all combine to make an estuarine system with few equals in the northern Gulf of Mexico. For these reasons, the use of information from other estuarine systems in the northern Gulf of Mexico has been kept to a minimum, and concerted effort has been made to center only on pertinent references. Adjacent waterbodies along coastal Louisiana undoubtedly contain many of the same suite of species encountered within the project area. However, physical parameters may be radically different. A summary of the pertinent data available on the project area is presented in Appendix D.

3.5.2.2.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renew Permits with Existing Conditions

Implementation of this alternative means the continuation of impacts currently affecting the East Cote Blanche/Atchafalaya/Four League Bay

system. One of the primary impacts of shell dredging activities on the benthos is the destruction of approximately 45,000 square feet of habitat, or slightly more than one acre of waterbottom per dredge per day. In the majority of the region, this means the benthos on a maximum of 2.4 acres of waterbottom are destroyed per day. In addition, turbidity plumes of very fine suspended material and fluid muds extend away from the dredge for variable distances, depending on a wide array of factors.

The impacts of shell dredging operations affect relatively small portions of the waterbottom at any one time, with initial stages of the recovery of the benthic community following within months. The community structure of the benthos of the project area is highly dynamic. The response of the benthos to shifting environmental conditions (e.g., increased river flow, passage of cold fronts, etc.) is very rapid, and is reflected in the community structure. Indications are that dredging activities have the effect of lowering species diversity for a period of time following the extraction of the shell resource. However, the natural responses of the benthic community to the high variability of the system probably account for wider, more drastic swings in the species diversity profile. These effected benthic communities, if environmental conditions allow, would probably return to pre-dredged community status within 2 years.

ALTERNATIVE 2 - Permit Denial (No Action)

If permits for the continuation of the removal of shell resources were not granted, any impacts which result from the action, adverse or beneficial, would cease. The benthic community within the bays would continue to be dominated by the dynamic physical conditions which control the estuaries. Periodic floods and low-flow years would continue to force the benthic community to respond by the shifting of dominant taxa from oligohaline to freshwater species. The typical estuarine community would continue to be forced out of the bays as freshwater flows increase, and naturally high turbidity resulting from winds, waves, and freshwater

inflow would continue. Any impacts associated with turbidity and fluid muds would no longer be evident.

ALTERNATIVE 3 - Closure of Bottom Half of Four League Bay

The closure of this region would reduce potential impacts to the benthos, and assure minimal disturbance from other shell dredging activities (e.g., the transferral of barges, operation of tug and crew boats, etc.)

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The reduction of shoreline restrictions from one-half mile to 1,500 feet in the upper half of Four League Bay only would have the same impact as Alternative 1. Approximately 606 acres of additional waterbottom would be made available for the recovery of shell. The impacts which are currently associated with the removal of shell would also effect the additional areas currently protected.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Within current operating constraints, the potential for four operating dredges to concentrate in western East Cote Blanche Bay exists. This level of dredging intensity would lead to the bottom of this area being disturbed at a much higher rate than the waterbottoms of adjacent bays. Implementation of Alternative 5 would assure a rate of disruption of the benthic community in a more equitable fashion.

3.5.2.3. **Oyster Reefs**

3.5.2.3.1. Existing Conditions

Oysters of the genus *Crassostrea* form large concentrations of shell within the oligo-haline reaches of most of the estuaries along the

southeastern and gulf coasts of the United States. These "reefs" provide millions of dollars of oysters annually and a firm substrate for the settlement of young oysters or other invertebrates. These larval oysters, or "spat", require a firm surface to metamorphose from the planktonic state, which is accomplished by the cementing of the organism to a firm substrate. These resultant reefs are often quite extensive in regions where currents carry sufficient nutrients and are able to carry off waste products.

The reefs are composed primarily of oyster shell with attached organisms, such as mussels, clams, and worms. They were extensively mapped by Thompson in the 1940's in connection with oil company interests. The reefs became stressed with fresh water and sediment in a zone extending from Oyster Bayou to Southwest Pass approximately 50 years ago. Growth of the reef zone halted 25-30 years ago as fresh water flow and sediment loads from the Atchafalaya River rapidly increased. The reefs were impacted by the fluid muds of prodelta clays in the 1950's and more recently by the silty clays of distal bar deposits associated with the growth of the Atchafalaya Delta. However, during periods of low river flow, salinities in the project area can be elevated to a point where optimal oyster growth occurs. When this happens, massive beds of oysters are formed in areas which may not have been suitable in previous years for oyster production. Unfortunately, these reefs are often eliminated by high flows of fresh water and sediments into the area the following year. Numerous such reefs have been verified by LDWF surveys in 1986.

No detailed maps of the oyster reefs of the coastal zone exist. Old maps produced within the body of previous reports and navigational charts are badly outdated, many of which still refer to reefs which have long since been buried or removed by shell dredgers. Thompson (1953) produced a chart which purported to show the vast oyster shell reefs of Atchafalaya and East Cote Blanche Bays. Since that time, however, large-scale changes in sedimentation rates, progradation of the

Atchafalaya delta, and removal of shell resources over the past 40 years have limited the applicability of these maps.

The value of submerged oyster reefs is an issue which also needs to be addressed. From scoping comments received during the public involvement phase of this study, it has become evident that a great many individuals feel that shell reefs buried beneath an overburden of mud have an intrinsic "value." This value has been attributed to the physical characteristics of the reef. In order to address these comments, an analysis of the biological, hydrological, geological, and economic "values" of submerged reefs follows.

The primary value of dead shell reefs from a biological viewpoint is the presentation of a firm substrate for the attachment of other oysters and invertebrates, conversion of suspended materials into flesh and pseudofeces, diversity of habitat for sessile and cryptofaunal invertebrates, and modification of current patterns. It would also logically follow that the hypothesis put forward by Sikora and Sikora (1983) regarding the enrichment of adjacent waterbottoms in the vicinity of oyster reefs has merit. However, all of these values become lost once the reef becomes buried and aerobic organisms no longer have access to the habitat.

From a geotechnical/geological viewpoint, shell reefs are of minimal value once they become buried under overburden. The presence of submerged shell reefs in the East Cote Blanche/ Atchafalaya/Four League Bay system would, in general, have a negligible effect on the geotechnical/geological aspects of the study area. A possible exception to this statement may be that a slight reduction in the subsidence rate/potential in the immediate vicinity of a submerged reef may be seen. Even this effect would be highly dependent upon the type and character of the overlying sediments; the depth of burial of the submerged reef; and the thickness (in depth) of the submerged reef. In addition, depending on the nature of the buried environment in which the reef is located, the degree and rate of reef decay would have an impact

on possible future induced subsidence. Other aspects of the value from a geological viewpoint, such as acceleration or retardation of delta development; increasing or decreasing of erosion rates (shoreline or other) due to possible "protection" of some sort by the submerged reef; or potential for future oil and gas resevoirs are not considered important to the overall geology of the area.

The value of submerged oyster reefs from a hydrological viewpoint are minimal. Shell reefs exposed above the mudline are recognized as having a major impact on the flow and tidal characteristics of many estuaries. When currents are no longer of sufficient force to carry significant quanities of sediments in suspension, exposed reefs may become buried. At this point the reef loses any and all effect on the hydraulics of the estuarine system. In order for a reef which has been buried to have any effect hydrologically, the overburden of mud must first be scoured away.

In summary, the submerged reefs in place offer very little contribution to the functions of the coastal ecosystem. Once buried, little or no significance can be attached to a reef from a biological, geological, hydrological, or economic viewpoint.

An economic good is considered to be anything external to man that is inherently useful, appropriable, and relatively scarce. The submerged oyster reef, in place, does not meet these specifications. As noted above, once the reef becomes covered with an overburden of mud, it serves no identifiable, useful purpose.

3.5.2.3.1. Impacts of Alternatives

ALTERNATIVE 1 - Renewal of Permits with Existing Conditions

Current restrictions for the operation of shell dredging in the project area include buffer zones surrounding oyster reefs exposed above the mudline in order to minimize damage due to the flow of material re-introduced following dredging.

The buffer zone is considered adequate by regulatory agencies because of the behavior of dredged materials when they are discharged back into the water. The greatest bulk of the suspended materials settle out of the water column within 500 feet of the dredge. This process may be substantially quickened in the brackish waters of the estuaries where oysters are most commonly encountered. This slightly saline water enhances ionization of the suspended materials, and quickens the subsequent aggregation and flocculation of the clay and silt particles which would otherwise remain suspended longer. This flocculation is a common occurrence in estuaries and a constantly shifting "flocculation zone" is often located near the outer limit of the bay system. Some of the intermediate-weight materials discharged from the dredging process may form a "fluid mud" which can disperse beyond the limits of the dredging activity. The characteristics of this mud are such that it generally moves by gravity flow and fills up the shallow depressions on the adjacent water bottoms of the area. Live oyster reefs are generally built upon the dead shells of former generations, and as such are elevated above the mudlines. This elevation is most often sufficient to minimize the impact of fluid muds on the live oyster reefs.

The necessary buffer zones which surround the live oyster reefs are adequate for their protection under most situations. Within the project area, the present "normal" situation is the result of the Atchafalaya River and the Wax Lake Outlet carrying 30% of the flow of the Mississippi River. This flow has lowered salinity regimes within the coastal region to the point that very few exposed oyster reefs in the area can normally support viable, healthy oysters. However, as with most estuarine systems, the "normal" year is more a reflection of a statistical average and is not very often seen in reality. During a succession of low-flow years, oyster reefs can flourish in areas that were not able to previously support oysters. These areas can become broad expanses of healthy oysters that yield many thousands of pounds of valuable flesh. However, a period of increased flow will once again decimate the reef to a point where very few healthy oysters remain. At this point, the reef is valuable to the invertebrates which make it their home and the fish

which feed off the invertebrates. The value of this now "dead" reef to oysters is that, in the event of low-flow years, a hard substrate ready for colonization by the transforming larvae, is readily accessible. However, if during the intervening years sedimentation covers the reef, it would lose all value to any transforming larvae.

Renewal of the permit with existing conditions would not have a significant impact on the few live oyster reefs which, in most years, are scarce in the bay system. Existing distance requirements around exposed oyster reefs (live or dead), are effective in limiting the effects of shell dredging. These limits allow for settling-out of the larger, most damaging (to an oyster) particles resuspended by dredging. Live oysters also typically settle on top of older reefs, effectively elevating themselves above the surrounding mud bottoms. Hence, the gravity flow of any fluid muds which may result from dredging, would have to flow greater than 1,500 feet, and move uphill to impact most live oyster reefs. The isolated, or "coon" oyster, scattered around the mud bottoms of the area may be covered by this fluid mud.

ALTERNATIVE 2 - Permit Denial (No Action)

If shell dredging operations were to cease, any potential impacts attributable to shell dredging, regardless of the magnitude, would cease. Naturally high turbidity, increasing fresh water inflow from the rivers, resuspension of materials, and rapid sedimentation rates would continue to limit the distribution of healthy, viable oysters.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would have minimal impact on live oyster reefs in the project area. It would insure that any potential impacts due to shell dredging activities, regardless of magnitude, would not affect the oysters beds in the lower end of Four League Bay.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay.

Due to the adequate areal restrictions which surround the live oyster reefs, this alternative would have no impact.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Same as Alternative 4.

3.5.2.4. **Endangered and Threatened Species**

3.5.2.4.1. Existing Conditions

Coordination has been initiated and maintained with both the U. S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) regarding the occurrence of threatened and endangered species in the project area and the potential impacts of shell dredging to any of these species. In a letter dated June 18, 1986, USFWS indicated that no endangered or threatened species under their jurisdiction would be impacted by the proposed activity and that no further consultation would be required.

In a letter dated July 8, 1986, NMFS provided New Orleans District with a list of threatened and endangered species under their jurisdiction that may be present and potentially impacted by shell dredging. The list consisted of the Kemp's (Atlantic) ridley sea turtle, *Lepidochelys kempi*, which is endangered, and the loggerhead sea turtle, *Caretta caretta*, which is threatened. NMFS advised the New Orleans District that a Biological Assessment should be prepared to identify potential impacts to these species as a result of shell dredging. A Biological Assessment has been forwarded to NMFS and is included as Appendix A to this EIS. The results of this assessment are summarized here.

Kemp's ridley and loggerhead sea turtles have been sighted in portions of the project area in the summer and fall months. However, no sightings have been made in the vicinity of operating shell dredges. During the majority of the year, even the slow-moving sea turtles would be expected to avoid the shell dredges and there is no evidence of sea turtles using any part of the project area during hibernation.

3.5.2.4.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

Based on present information, the impact of shell dredging on Kemp's ridley and loggerhead turtles in coastal bays is considered negligible. In a letter dated 9 December, 1986, NMFS concurred with the assessment.

ALTERNATIVE 2 - No Action (Permit Denial)

Cessation of shell dredging in the coastal zone would eliminate any possibility of impacts, regardless of magnitude, to endangered and threatened species in the project area.

ALTERNATIVE 3 - Closure of the Bottom of Four League Bay

Implementation of this alternative would eliminate all possibilities of impacts, regardless of the magnitude, to the endangered and threatened species which may use the bottom half of Four League Bay.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The allowal of shell dredging within 1,500 feet of the shoreline in the upper half of Four League Bay only would have little impact on threatened and endangered species. The possibility of impact on these species would be only slightly increased over the maintenance of the 2,500 foot shoreline restriction.

ALTERNATIVE 5 - Reduction of Dredging Intensity in Western East Cote Blanche Bay

Under present limitations, a maximum of four dredges could operate in the western half of East Cote Blanche Bay. The alternative to limit this number to a maximum of two would lessen the possibility of a dredge encountering any threatened or endangered species.

3.6. ECONOMIC ENVIRONMENT

3.6.1. **Business and Industrial Activity**

3.6.1.1. Existing Conditions

Coastal Louisiana is a land rich in commercially important minerals and generously endowed with a variety of fish and wildlife resources. As a result, the economy of the area is founded on a base of natural resources, along with rice, soybeans, other grains, and sugarcane harvested from the area's alluvial ridges. Significant mineral deposits include crude petroleum, natural gas, natural gas liquids, sulfur, salt, and oyster shells. Other important commercial activities center around fish and wildlife resources. Shrimp, menhaden, oysters, and crabs are important saltwater varieties while crawfish, catfish, and buffalofish are the dominant freshwater varieties.

Shell (sometimes reported as "stone") has been an important source of aggregate and calcium-carbonate for use in the area's economic development. The most detailed information available regarding Louisiana's shell industry has been reported by the Louisiana Wildlife and Fisheries Commission and the agency which replaced it, the LDWF. These agencies, along with the Department of Natural Resources (DNR), have had significant authority and responsibility in the state's regulation of the industry. To document its procedures, the Louisiana Wildlife and Fisheries Commission published a report in December of 1968 outlining The History and Regulation of the Shell Dredging Industry in Louisiana. As

discussed in that report, the state's regulation of shell production began in 1913 and 1914, in part to finance the Wildlife and Fisheries Commission. The state's records of annual production date back to 1916, increasing from 300,000 cubic yards to 1,5 MCY by 1925, and 5,200,000 cubic yards by the mid-1960's. Table 4 lists the major uses of both clam and oyster shell in Louisiana in 1968. At that time, the volumes of clam shells harvested from the lakes and oyster shells harvested from the central gulf coast were about the same. Table 5 provides a list of oyster and clam shell uses in Louisiana during the period 1980-1985.

Table 6 on page EIS-59 compares the combined production and value of both clam and oyster shells harvested in Louisiana during the 1960's with trends in other Gulf Coast states. The market value of shell during the 1960's was influenced by a wide range of factors including such things as transportation costs, construction trends, oil and gas production, resource availability, changes in material specifications, environmental concerns, governmental regulation, and an apparent shake-out in the industry encouraging greater diversification of individual companies (Arndt, 1976). Production in Louisiana has followed the same pattern of decline experienced in Texas and other gulf states. From 1975 to 1985 oyster reef shell production declined from 4.8 million cubic yards to less than 3.2 million cubic yards; however, the combined production of both clam and oyster shell harvested from state waters was still slightly more than 6 million cubic yards in 1985 (LDWF, 1986).

For purposes of this EIS, the economic study area is considered to be the three parishes adjacent to the shell dredging sites (Terrebonne, St. Mary and Iberia). However usage of the dredged oyster shells can be found throughout all of coastal Louisiana.

Recent studies indicate a relatively sharp increase in the price of shell, reflecting not only its importance to the local economy, but also increases in transportation costs and the rising price of fuel. A 1986 analysis by Dr. William Barnett II, prepared for the Louisiana Shell Producers Association in conjunction with this study, estimates the price

Table 4

Uses of Clam and Oyster Shell on a Percentage Basis

General Construction	32.6%
Road Construction	31.4%
Cement	17.4%
Petroleum and Chemical Production	11.0%
Lime	6.8%
Agricultural Uses (Chicken Feed)	0.4%
Glass	0.4%

Source: Louisiana Wildlife and Fisheries Commission, 1968.

Table 5

Uses of Clam and Oyster Shell on a Percentage Basis

ITEM	Percent Used
General Construction and Maintenance (Roadway Base Course, Parking Lots, Roads, Drill Pads, Levees)	80%
Acid Neutralization, Smoke Stack Emission Control, Chemicals, Pharmaceuticals	10%
Lime	5%
Oyster Reef Cultch	5%

Source: Louisiana Shell Producers Association, New Orleans, La, 1986.

Table 6

Recorded Shell Production and Value in the Gulf Coast Region, by States, 1960-69
(Production in short tons)

	Louisiana		Texas		Fla., Ala., Miss.[1]		Total	
Year	Production	Value	Production	Value	Production	Value	Production	Value
1960	4,691,114	$ 8,881,608	10,304,451	$15,798,494	2,758,658	$6,088,093	17,754,223	$30,768,195
1961	4,641,276	7,655,928	10,531,247	15,372,759	1,564,459	4,651,429	16,736,982	27,680,116
1962	5,711,481	8,066,647	10,072,803	14,701,243	3,188,868	5,936,924	18,973,152	28,704,814
1963	5,408,182	7,961,135	9,300,749	13,306,513	2,782,641	5,037,298	17,491,617	26,304,946
1964	5,459,044	7,227,803	9,989,946	15,077,078	3,283,067	5,084,940	18,732,057	27,389,821
1965	7,452,421	10,905,244	9,689,357	15,355,914	3,231,074	4,946,184	20,372,825	31,207,342
1966	8,091,318	11,252,763	9,364,618	12,839,355	3,090,339	5,016,135	20,546,275	29,108,253
1967	7,599,395	11,174,114	10,776,368	15,417,035	2,845,353	4,639,158	21,230,116	31,230,307
1968	9,387,333	11,748,503	7,851,155	10,784,751	3,095,000	4,268,601	20,333,488	26,801,855
1969	9,237,470	1,891,976	7,177,148	8,577,868	2,839,156	5,836,771	19,253,774	26,286,615

[1] Combined to avoid revealing individual company confidential information.
Source: R. H. Arndt, 1976.

of shell at $9.50/cu yd. The annual harvest of 3,000,000 cu yd of shell, sold at that price, would be valued at $28,500,000. At the present time, Louisiana is the only state in the Gulf area harvesting shells for industrial purposes. The study indicates that increases in restrictions by regulating authorities have resulted in substantial reductions in the volume of shell harvested. This has caused the per unit operating cost to increase, which have, by necessity, been passed on to users in the form of higher prices.

Activities of this basic materials industry tend to have a multiplier effect, influencing indirectly other businesses and industries. Including total sales, resales, transportation costs, royalties and severance taxes, state and local sales taxes, and estimating a multiplier factor of three, overall economic effects of an annual production of 3,000,000 cu yd of clam shell could be on the order of $102,678,000 (Barnett, 1986a).

"Extensive deposits of dead reef oyster shell are known to exist throughout the bays of coastal Louisiana. The entire permit area has not been completely explored, but shell reserves (in the coastal region) totaling approximately 15 million cubic yards... have been surveyed and mapped by the industry. This volume reflects only a small percentage of what industry geologists believe to be the total shell reserves located in the areas permitted for dredging" (Douglass, 1986).

3.6.1.2. Impacts of Alternatives

<u>ALTERNATIVE 1</u> - Renew Permits with Existing Conditions

Renewing the permit would provide the coastal region with an important source of calcium carbonate and construction aggregate. Louisiana shells, which are 99% calcium carbonate, are one of the best sources easily and readily available in the state (Douglass, 1986).

The harvested shell would continue to be used in the manufacture of cement, glass, chemicals, wallboard, chicken and cattle feed, agricultural lime, road construction, water purification, pharmaceuticals, petroleum and other chemical and miscellaneous products.

Permit issuance would also allow continuation of current dredging activities in the central coast with the current limitations imposed by the various state and federal regulatory authorities. As discussed by Juneau (1984) and others, the LDWF and DNR have developed a monitoring system for measuring and controlling environmental impacts which may be felt to be damaging to the resources under their regulatory authority.

As the harvest of shell declines, the demands for alternate sources of aggregate would tend to increase, and this source of raw material would gradually decline as it has in other states.

ALTERNATIVE 2 - Permit Denial (No Action)

The immediate impact to business and industrial activity would be the loss of shell as a source of calcium carbonate and as an aggregate for construction. Alternative sources of material supply would be required for those industries previously mentioned. The primary alternative material, limestone, would have to be imported from out of state at an increased cost of roughly 50% to the users. Although competing materials are to some degree available, shell's cost and functional characteristics outperform those of limestone and others materials in many uses (Douglass, 1986).

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Business and industrial activity would not be immediately affected as dredging currently does not occur in this area. Business activity could be impacted in the future should reserves in other areas be exhausted. Reserves in the bottom half of Four League Bay have not been determined,

however, the life of the shell industry would be shortened if these reserves are eliminated forever.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

This reduced restriction would not impact overall business and industrial activity until reserves in other areas have been depleted. The estimated additional 2.5 MCY of shell reserves would then meet the need of the various industry users for almost a year, at current dredging rates (Barnett, 1986a). At a price of $9.50 per cubic yard, the gross value of an additional 2.5 million cubic yards would be $23,750,000.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

As the permit currently exists, a maximum of 4 dredges could operate in the area at any one time, although current demand can support only 2 dredges. Therefore business and industrial activity would not be impacted under this alternative unless economic conditions improved to where two dredges could not meet the demand for shells. The Barnett economic analysis does not predict an increase in annual demand.

3.6.2. **Desirable Regional Growth**

3.6.2.1. Existing Conditions

The economy of southern Louisiana during the last two years has been in a depressed condition. Declining oil prices have devastated the oil industry and those industries dependent upon oil activities. The petroleum industry will likely never return to those days when it was the dynamic force in the Louisiana economy providing a ready source of employment with good wages.

While oil field activities have been the catalyst for economic growth in the region, other factors have made a contribution. These include

such things as improvements in technology, population increases, abundant natural resources and cheap water transportation.

3.6.2.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

As indicated in the previous sections, dredged shells have been an important source of aggregate and raw material for construction and manufacturing for many years and as such have contributed to the area's overall economic development.

Shells serve a unique purpose in southern Louisiana due to the soft, unstable terrain. As a base for roads and other structures in this area, shells are mechanically and economically the material of choice. The cost and undesirable functional characteristics of competing materials create a net advantage to the state from the utilization of shells (Douglass, 1986).

ALTERNATIVE 2 - Permit Denial (No Action)

Regional growth would be adversely impacted by denial of the permit. At a time when State and local governments are facing severe budgetary problems, denial would force them to switch to alternative sources of construction aggregate. "This would be a problem even in the best of fiscal times because of shells superiority as a road building material in southern Louisiana. The fact that alternative materials would increase costs approximately 50 percent only magnifies the injury" (Barnett, 1986a). Regional growth will also be impeded by the loss of millions of dollars in royalties, severance taxes, sales taxes and income taxes by the State, local, and Federal governments. To some degree, losses locally would be offset by growth in other areas which supply alternate materials.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Regional growth would not be immediately impacted by this alternative. The reserves in this part of the bay might be needed in later years.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

This alternative would make available an additional 2.5 MCY of reserves that could be mined if needed for economic growth and prolong desirable regional growth.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Regional growth would not be impacted by this alternative. Only two dredges are currently in the area.

3.6.3. Employment/Labor Force/Displacement of People

3.6.3.1. Existing Conditions

Approximately 160 jobs are directly involved with shell dredging in the study area. An estimate of people whose jobs indirectly depend on the shell industry numbers about 480. A loss of these jobs would cause a displacement of people since some would be forced to migrate to other areas, due to the poor economic conditions in southern Louisiana.

In the last two years, the study area, as well as the state, has become an area of high unemployment due to the depressed state of the oil industry. Table 7 shows employment data for the state and the study area during the 1980's. As indicated in the table, 1 out of every 5 people in the study area labor force is currently unemployed. Also, the total labor force is becoming smaller, thus indicating workers are leaving the study area for more healthy economic climates.

TABLE 7

CIVILIAN LABOR FORCE

(1,000)

Area	Aug. 1986				Aug 1984				1980 Census			
	Labor Force	Empl.	Un-Empl.	Un-empl. Rate	Labor Force	Empl.	Un-Empl.	Un-empl Rate	Labor Force	Empl.	Un-Empl.	Un-empl Rate
Louisiana	1986.5	1739.3	247.2	12.4	1955.9	1,768.9	187.8	9.6	1744.1	1,639.4	104.7	6.0
Iberia Par.	32.2	26.0	6.1	19.0	36.7	32.7	4.0	10.9	26.6	25.1	1.5	5.5
St. Mary Par.	33.1	26.0	7.1	21.4	33.6	29.8	3.8	11.4	27.4	26.1	1.3	4.6
Houma-Thibodaux	75.3	61.5	13.8	18.3	84.7	76.7	8.0	9.4	72.3	69.9	2.4	3.4

1 Includes Lafourche and Terrebonne Parishes

Sources: State of Louisiana, Dept. of Labor, "Louisiana Labor Market Information", 1984, 1986. U.S. Dept. of Commerce, Bureau of the Census, 1980 Census of Population," Characteristics of the Population, General Characteristics, Louisiana.", 1981.

The shell industry in Louisiana employs approximately 460 people and has an annual payroll of $8.7 million. 160 of these jobs are located in the project area. Industry officials estimate these jobs to provide 410,000 manhours of work.

Although there is no way to determine the exact number of jobs indirectly involved with shell dredging, industry economists estimate an employment multiplier of 3, i.e., 477 jobs, depend to some extent on the industry. (Barnett, 1986a).

These jobs would be in such fields as road contractors, raw material suppliers, manufacturing companies, shipyard repair facilities and equipment vendors.

3.6.3.2. Impacts of Alternatives

<u>ALTERNATIVE 1</u> - Renew Permits with Existing Conditions

There would probably be no change in employment over the near term, followed by a decline in proportion to a decline in a producable reserve. The state of the economy in coastal Louisiana could alter the expected employment figures depending upon the demand for shells. A continued depressed petroleum industry would lessen the demand for shells thereby creating a further decline in employment. Should the petroleum industry recover to some degree, the demand for shells could increase, as could employment in the industry.

<u>ALTERNATIVE 2</u> - Permit Denial (No Action)

Industry officials estimate that 143 of the 160 jobs directly involved in shell dredging would be lost. Those industries which service and supply the shell dredging industry would also lose some employment positions. Loss of any jobs in the area with its current high unemployment rate would be very damaging. To some extent, losses locally

could be offset by increased employment in other industries which supply alternative materials, or in other areas of the United States.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would have no immediate impact on employment as dredging has not recently occurred in this area. It could have an impact on future employment opportunities should shell reserves in other areas be exhausted. However, reserves in the bottom half of Four League Bay have not been determined.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

As with Alternative 3, this reduced restriction would have no immediate impact on employment. The addition of an estimated 2.5 million cu. yds. of shell reserves would provide employment opportunities in the future when shell deposits in other areas are exhausted.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

As the permit currently exists, a maximum of four dredges could operate in the area at any one time. However, two of these dredges have not been in operation since 1983. Therefore, this alternative would have no immediate impact on employment. Should economic conditions warrant a greater demand for shells, this reduction would prohibit the operation of these dredges and eliminate accompanying employment opportunities.

3.6.4. **Property Values**

3.6.4.1. Existing Conditions

Real property values in the area have been falling due to the depressed condition of the State and local economies. In addition, the shell companies currently have an investment of approximately $60 million

in dredges, boat, barges, cranes, and other equipment in Louisiana. Of this total, nearly half, or $28 million, is currently in use in the project area.

3.6.4.2. Impacts of Alternatives

ALTERNATIVE 1 Renew Permits with Existing Conditions

A renewal of the permit under existing conditions will allow dredging operations to continue as is, thus capital equipment can be maintained and annual debt obligations can be met. Continued earning capacity will maintain the value of capital equipment engaged in dredging.

While a continuation of dredging will have little direct impact on real property values, it will prevent the unemployment of those involved in shell dredging. Increased unemployment would result in more outmigration and in additional housing becoming available, thereby further depressing the value of property.

ALTERNATIVE 2 - Permit Denial (No Action)

Industry officials estimate a salvage value of nearly $15 million in capital equipment if the permit is denied and dredging operations are discontinued. Thus, there would be a loss of $13 million of the existing $28 million in the value of dredging equipment. It is not possible to accurately estimate the magnitude of the impact upon the value of residential housing which would result from the unemployment created by the discontinuance of shell dredging operations. However, the value of such properties has been decreasing due to the depressed condition of the economy. The increase in unemployment would result in additional housing going on the market, thereby further depressing the value of such property. Loss of adequate wages will also impact the homeowner's ability to properly maintain his residence, which will also tend to lower it's value.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would have no impact on property values.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

There would be no immediate impact on property values. The addition of an estimated 2.5 MCY of shell reserves would have favorable impacts on property values should mining of this area be required.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

There would be no impact on property values. This reduction would preclude any favorable impacts to property values should economic conditions improve to justify a need for an additional two dredges.

3.6.5. **Public Facilities and Services/Transportation**

3.6.5.1. Existing Conditions

Public facilities and services influencing, or influenced by, shell dredging are primarily roads, streets, channels, bridges, docking facilities, and related activities of municipal, state, and federal regulating authorities.

Over 80% of total shell usage during the 1980-1985 period was for general construction and maintenance (roadway base course, parking lots, roads, drill pads, and levees) (Douglass, 1986). Assuming an annual production of 3 MCY of shell production in the study area, approximately 2.4 MYC was used for these purposes. The majority of this usage was for public construction and maintenance of roadways. Shell cost and functional characteristics outperform competing materials for these tasks.

In south Louisiana there is a shortage of aggregates for use in highway and airport construction. All aggregates, except shell, must be imported from out of state. The nearest limestone quarries are located in Alabama, but most of the limestone now used in Louisiana comes from Missouri and Kentucky where it can be shipped by less expensive water transportation (Douglass, 1986).

The Louisiana Department of Transportation and Development (DOTD) uses shell as a base course material, in asphaltic concrete, as a shoulder material and as an embankment in marsh and swamp areas. Shell products, such as lime and portland cement are also used. DOTD's evaluation indicates that shell has engineering properties that make it an extremely useful building material. Because of its shape, it provides high particle interlock, which results in high shear strength (resistance to movement). This quality makes shell a superior material for bridging over soft foundations, such as marsh or swamp.

DOTD geologists say that shell aggregates produce a base course equal to that of crushed stone in load-carrying capacity. Since crushed stone has to be imported in large quantities for use in base course construction, use of shell results in considerable savings to the public. When stabilized with cement, shell will produce a base course that is superior to any aggregate available in Louisiana. In parts of the state where shell is available, use of a cement stabilized shell base course results in reduced thickness due to additional strength developed.

The DOTD, in cooperation with L.S.U., conducted research on building "Floating Embankments" through marsh and swamp for the relocation of U.S. 90 west of Raceland, using shell as the embankment material. Based on this research, they concluded that it would only require half as much shell, compared to sand, to construct an embankment in this marsh area. In addition, the required right-of-way for a shell embankment is approximately 50% less than for a sand embankment. The reason for less right-of-way for shell, compared to sand, and for less quantity of shell,

is the fact that the shell embankment requires no berms for stability, as does the sand. This smaller right of way required also lessens the environmental impacts of the project. On one project alone, this resulted in a savings to the taxpayers of some $17,000,000 (DOTD, 1986).

3.6.5.2 Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

Continued production would provide aggregate used in construction and maintenance of roads, levees, parking lots, etc. Public services would continue to be enhanced through the collection of royalties and severance taxes.

ALTERNATIVE 2 - Permit Denial (No Action)

This would cause an immediate impact on highway and airport construction in southern Louisiana (LDTD, 1986). Other aggregates, with higher transportation costs, would have to be imported from other states. Some of the engineering properties that make shell a useful building material, such as high particle interlock, are not found in other aggregates. In a marsh and swamp area, such as parts of southern Louisiana, twice as much sand is required to construct an embankment than when shell is used. In addition, the required right-of-way for a shell embankment is approximately 50% less than for a sand embankment. Both of these factors amount to added expenses to the taxpayers if shells are not available.

Public services will also suffer from the loss of royalties and severance taxes collected by state government. Increased outlays for unemployment payments and other social services for those employees losing their jobs would further add to local government budgetary problems and reduce the availability of some services overall.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This would have no immediate impact on public facilities and services. It would prohibit the use of shell from this area along with its accompanying revenue to government agencies should reserves in other areas be exhausted.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

This alternative would expand reserves in the area by 2.5 MCY. Thus, almost another year supply of shell would be available for use in general construction and maintenance of such things as roads, runways, levees, etc.

It also would benefit public services when these reserves are dredged by providing revenues to certain government agencies.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

There would be no impacts to public facilities and services. If implemented, a slight reduction in future services may result.

3.6.6. Tax Revenues

3.6.6.1. Existing Conditions

An important economic contribution of the shell dredging industry to the state of Louisiana is the millions of dollars paid through the years in royalty and severance taxes (Figure 4). Table 8 shows shell production volumes and royalties collected from 1975 through 1985. Severance taxes collected from the harvest of oyster and clam shell, combined, have generated additional revenue averaging about $312,000 annually. Data shown for oyster shell pertain to dredging in the

Table 8

1975 - 1985 INCLUSIVE CLAM AND REEF SHELL
Production, Royalty and Texas

	CLAM		OYSTER		TOTALS		TOTAL
Year	Production Cubic Yards	Royalties Paid	Production Cubic Yards	Royalties Paid	Production Cubic Yards	Royalties Paid	TAXES COLLECTED (Clam & Oyster)
1975	7,374,059.89	$1,511,232.40	4,806,506.03	$742,390.24	12,180,565.92	$2,253,622.64	$432,743.74
1976	6,648,132.47	1,362,235.64	4,615,746.72	782,314.89	11,263,879.19	2,144,550.53	385,940.38
1977	6,078,527.96	1,245,893.92	4,348,424.72	749,729.74	10,626,952.68	1,995,622.66	364,112.10
1978	6,041,969.83	1,238,603.75	4,124,892.99	683,237.21	10,166,862.82	1,921,840.96	363,294.90
1979	5,546,539.83	4,168,981.17	3,994,149.37	657,569.39	9,540,689.20	1,826,550.56	337,163.55
1980	5,066,040.06	1,089,198.37	3,560,458.21	583,537.19	8,626,498.27	1,672,735.56	286,260.48
1981	4,857,931.89	1,044,455.48	3,391,911.49	571,248.26	8,249,843.38	1,615,703.74	282,198.78
1982	3,897,249.10	1,031,543.76	2,446,141.11	613,615.90	6,343,390.21	1,645,159.66	259,166.18
1983	3,331,056.21	1,049,282.70	3,287,296.04	859,548.51	6,618,352.25	1,908,831.21	199,107.07
1984	3,302,710.78	1,079,976.49	3,198,864.27	868,740.47	6,501,575.05	1,948,716.96	217,407.73
1985	2,932,076.70	990,922.96	3,163,058.14	897,623.35	6,086,134.84	1,888,546.31	310,506.70
	55,067,285.72	$12,813,325.64	41,137,449.09	$8,009,555.15	96,204,734.81	$20,821,880.79	$3,437,901.61

Re: Louisiana Wildlife and Fisheries Commission; Louisiana Department of Revenue and Taxation, Baton Rouge, La.

coastal area while data on clams are from Lakes Pontchartrain and Maurepas.

Royalty rates for oyster shells have increased from a range of 12 to 20.5 cents/cu.yd. in 1975 to a range of 28 to 33.9 cents/cu.yd. in 1985.

3.6.6.2. Impacts of Alternatives.

ALTERNATIVE 1 - Renew Permits with Existing Conditions

This alternative would allow continued dredging of shell and continued collection of royalties and severance taxes by the state of Louisiana. Production over the last ten years has shown a downward trend and one would expect this to continue (Figure 3). However, due to increases in royalty rates, taxes paid to the state for oyster shells were greater in 1985 than in 1975. Thus, continuation of this production would insure much needed revenue to a state beset with budgetary deficit problems.

ALTERNATIVE 2 - Permit Denial (No action)

The loss of royalties and taxes by state and local governments would add to the already sizeable governmental budgetary deficit problems. Increased outlays for unemployment payments and other social services would further add to budgetary problems. Corporate income tax, as well as personal income taxes, would also be lost to the Federal Government.

Royalties on alternative aggregates (limestone) range from 9 to 45 cents/cu. yd. However, these royalties are paid to the land owners, therefore govermental units would not benefit unless they owned the land where the stone is quarried. To the degree that alternative sources of aggregate and calcium carbonate could economically replace the demand for shell, taxes generated in the production of the alternative material would contribute to the tax base at the production site where the product is generated.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

There would be no immediate impact on tax revenue as this area is not currently used for production. This alternative would have future adverse impacts on revenues should other area reserves be exhausted and this area not be available for dredging.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

The estimated 2.5 MCY of shell would provide additional tax revenue to the state should this new area be mined. Using an average of 30 cents/cu.yd., this would add $750,000 to state revenues.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

There would be no immediate impact to tax revenue because only two dredges have been operating in this area for the last 3 1/2 years. This alternative would negate the opportunity for additional tax revenue from the operation of the other 2 dredges should the demand for shells warrant their use.

3.7. SOCIAL ENVIRONMENT

3.7.1. **Esthetic Values**

3.7.1.1. Existing Conditions.

Esthetic values in the project area center around the quality of the water, which is naturally very turbid. As indicated in other sections of this document, there is a tremendous amount of natural suspended sediment which is derived from the high freshwater inflow of the Atchafalaya River and Wax Lake Outlet.

3.7.1.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permit with Existing Conditions

The most significant esthetic value affected by shell dredging are in the immediate vicinity of the dredging operations. Dredging impacts water quality through resuspension of bottom sediments into the bay water column. An obvious and immediate result of this resuspension is an increased turbidity in a localized area around the dredge. Studies have shown that most of the heavier particles settle out rapidly, with very little of the suspended material carried beyond 1,200 feet of the discharge. This distance is highly variable and dependent on a complex interaction of many factors such as winds, waves, tides, salinity, current patterns, etc. As there is no dredging within one half mile of the existing shoreline, this increased turbidity would be noticed only by those on the dredge or in a boat nearby.

ALTERNATIVE 2 - Permit Denial (No Action)

This alternative would cause all shell dredging operation to cease, thereby eliminating this source of turbidity along with any adverse impacts to esthetic values.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would have no impact on esthetic values as no dredge-related turbidity would be created in the area.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

With this alternative, if certain conditions existed pertaining to winds, waves, tides, salinity, current patterns, etc., suspended material from the dredge discharge might be noticed on the shore. However since there is no urban development along this shoreline adverse esthetic impacts would be very minor.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

This would not have any immediate effect on esthetic values because there currently are only two dredges operating in East Cote Blanche Bay. Possible increased future turbidity would be avoided.

3.7.2. Archeology/Cultural Resources

3.7.2.1. Existing Conditions

Under current regulations and leases, if any archeological or historical material (i.e., pottery, bone, ship fittings, timbers, etc.) are encountered, the locations of these finds will immediately be mapped and the State Historic Preservation Officer (SHPO) will be notified. Dredging will be discontinued in that area until SHPO approval is given.

3.7.2.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permit with Existing Conditions

Implementation of this alternative would not modify in any way the method of shell extraction or impose additional hardships on the industry.

ALTERNATIVE 2 - Permit Denial (No Action)

Same as Alternative 1.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Same as Alternative 1.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

Same as Alternative 1.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Same as Alternative 1.

3.7.3. **Desirable Community Growth**

3.7.3.1. Existing Conditions

Desirable community growth is linked to a variety of interdependent factors, including such things as stable source of employment and income; adequate utilities; the maintenance of streets and sanitation; police, fire, and flood protection; health care; and high quality education. Poor economic conditions in the area have adversely affected many of these factors.

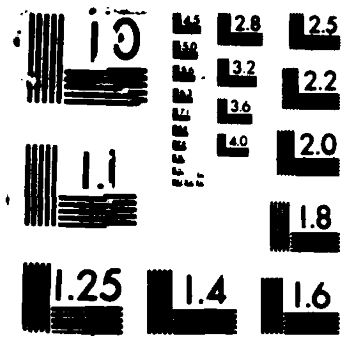
3.7.3.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

Allowing the continued harvest of shell as currently authorized would result in the continued employment and income generated both directly and indirectly by the industry. Certain services provided by government units would continue to be funded by royalties and severance taxes collected from the shell industry. The continued availability of relatively inexpensive shell for construction and other uses would help to sustain economic growth in local areas.

AD-A181 854 OYSTER SHELL DREDGING IN ATCHAFALAYA BAY AND ADJACENT WATERS LOUISIANA DR (U) ARMY ENGINEER DISTRICT NEW ORLEANS LA G D GOEKE APR 87 2/4

UNCLASSIFIED F/G 13/2 NL


1.0
2.8
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ALTERNATIVE 2 - Permit Denial (No Action)

If shell dredging is no longer permitted, the higher cost of alternative material would further discourage growth, particularly in communities experiencing the adverse economic effects from the decline of the oil industry.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

Community growth would not be immediately impacted by this alternative. It would be hampered if reserves in this part of the bay were needed to sustain the industry.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

There would be no current impact on community growth. The additional 2.5 MCY available for mining could potentially maintain growth when other reserves are exhausted.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Community growth will not be impacted as only two dredges currently operate in the area. Possible future growth would be limited if conditions improved to allow the use of 4 dredges.

3.7.4. Community Cohesion

3.7.4.1. Existing Conditions

Two of the most significant factors influencing community cohesion in any area are stable employment and high income. In the study area there are 160 jobs directly involved in shell dredging with an annual payroll of over $3 million (Barnett, 1986a). Industry economists estimate there are 3 times as many people whose jobs to some extent depend upon this

industry. Thus, the applicants are important in benefitting these two facets affecting community cohesion.

There is, however, concern in the community over the effects dredging may have on delta building and shoreline erosion. The USFWS has suggested that the trenches left by the shell dredgers may cause storm waters to be directed to the Louisiana Coast. These concerns are addressed in other parts of this DEIS.

3.7.4.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renew Permits with Existing Conditions

The employment and income generated both directly and indirectly from the shell dredging industry would contribute to positive community cohesion. Government service would continue to be funded from royalties and severance taxes collected from dredging companies, as well as from income taxes on individuals and corporations employed in dredging. Certain individuals in the community would continue to register concern over possible adverse environmental impacts.

ALTERNATIVE 2 - Permit Denial (No Action)

Permit denial would have adverse impacts on the social harmony of the community insofar as it would result in the loss of employment and income of some 160 wage earners. The effects would tend to be particularly severe at this time due to the poor economic conditions in the area. Concerns over possible adverse environmental impacts resulting from the dredging would be reduced.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would have no impact on community cohesion. Both beneficial and adverse impacts could result if these eliminated reserves are needed at a later date to sustain the industry.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

This alternative would have a beneficial impact on employment and income in the industry by making available an additional 2.5 MCY of shell. This in turn would benefit community cohesion when these reserves are mined. There would be no additional adverse environmental concerns

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Community cohesion would not be immediately impacted by this alternative since only two dredges have operated in the area since 1983. There would be possible future impacts on community cohesion if conditions were to improve enough to allow future dredges.

3.7.5. Noise

3.7.5.1. Existing Conditions

The only significant noise levels are those in the immediate vicinity of dredging operations. No dredging may be conducted within a one-half mile buffer zone which extends out from the existing shoreline, and there are no developed areas near the dredging operations. Therefore adverse noise levels would impact only those workers on the dredge or persons boating nearby. Studies in Mobile Bay on a comparable dredge indicate that noise levels are in the 100 decibel range in the engine room and 80 decibels on upper decks. Noise levels of the operating dredge were 60 decibels at a distance of 2,000 feet. Noise levels of 80 decibels or higher for sustained periods of time become injurious to health and impair hearing. Dredge personnel are required to wear ear plugs, to prevent hearing loss, when working near these high decibel levels.

3.7.5.2. Impacts of Alternatives

ALTERNATIVE 1 - Renew Permits with Existing Conditions

Adverse noise levels, described in the previous section, will continue to impact those on or in the immediate vicinity of the operating dredge. No one else will be impacted as no dredging is allowed within one-half mile of the existing shoreline.

Permit denial will alleviate any adverse noise impacts to those on the dredge or anyone nearby.

ALTERNATIVE 2 - Permit Denial (No Action)

Permit denial will alleviate any adverse noise impacts to those on the dredge or nearby.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

This alternative would prevent any dredging and associated noise levels in the area.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

This alternative would result in some noise reaching shore. However, there are no developed shorelines along upper Four League Bay. Therefore, no individuals would be impacted.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

This would not reduce the potential of increased noise levels over that found in the adjacent bays, where a maximum of two dredges can operate.

3.7.6. Recreation

3.7.6.1. Existing Conditions

The study area provides opportunities for a variety of outdoor-oriented recreational activities, with consumptive activities including hunting and fishing. Saltwater fishing is popular in the area, as is a sport shrimping and crabbing. Non-consumptive activities in the area include recreational boating, primitive camping, and various forms of wildlife-oriented recreation (i.e., bird watching). On Marsh Island, the refuge provides consumptive and non-consumptive opportunities, however, it is accessible only by boat. The wooded swamps, marshes and associated estuarine water bodies of the coast are heavily used at certain periods of the year by hunters and fishermen. In spite of the fact that automobile access to the coast is severely limited, the East Cote Blanche/Atchafalaya/Four League Bay area is a productive region in terms of recreational opportunities.

Recreational fishing and shrimping is by far the most significant and heavily pursued activity in the project area. In the adjacent parish of St. Mary, 7,346 resident and non-resident fishing licenses and 611 recreational shrimping licenses were issued in the 1984-85 season. In Terrebonne Parish, 17,202 resident and non-resident fishing licenses and 1,656 recreational shrimping licenses were issued. Most of the fishing that occurs is accomplished by boat, which is reflected by the 17,458 recreational motor boat registrations issued by the Louisiana Department of Wildlife and Fisheries in St. Mary and Terrebonne Parishes during the 1984-85 season. These numbers of fishing and shrimping licenses issued, along with the number of motor boat registrations, provides a potential for 26,815 recreational fishermen and shrimpers using 17,458 motor boats in adjacent parishes. This motor boat figure is provided to give an order of magnitude to the potential users that fish and shrimp waters of the study area. Although these boats may not exclusively use the water of the study area (use occurs in other parts of these parishes), the region is highly used.

3.7.6.2. **Impacts of Alternatives**

ALTERNATIVE 1 - Renew Permits with Existing Conditions

This alternative would have little to no effect on recreational fishing, shrimping, and crabbing. Sporting activities, such as those mentioned above, and other recreational pursuits (e.g., boating and skiing) will not be adversely impacted. A transferral of use would occur from an area in which a shell dredger is working to an undisturbed area in the vicinity. No long-term adverse impacts would be realized in the recreation environment.

A reported concentration of fish and shrimp in the vicinity of the active dredges has led many recreational fishermen to intentionally station themselves in the vicinity of active dredges when fishing. The mechanical disruption of the bottom and the associated fauna appears to attract larger fish and shrimp. The dislocated bottom animals provide easy prey for many larger, opportunistic fish. However, if an attempt is made to pull a shrimp trawl through the resultant trench, the unconsolidated bottom immediately behind the dredge may result in the loss of hardware for the recreational or commercial shrimper.

ALTERNATIVE 2 - Permit Denial (No Action)

This alternative would have no impact on the recreational activities of the study area. There would be no chance of user conflict. However, any beneficial uses the fisherman may derive from the proximity of the dredge would also be lost.

ALTERNATIVE 3 - Closure of the Bottom Half of Four League Bay

The impacts of this alternative would be the opening up of the area to the exclusive use of the recreationist. Any potential for user conflict in the lower half of Four League Bay would be eliminated.

ALTERNATIVE 4 - Reduce Shoreline Restrictions in Upper Four League Bay

Implementation of this alternative would have no impact on recreational activities.

ALTERNATIVE 5 - Reduce Dredging Intensity in Western East Cote Blanche Bay

Minor impacts on the use of the region would be the effect on implementation of Alternative 5. At most, a transferral of use by the recreational user to a "less-crowded" area may result.

3.8. CUMULATIVE IMPACTS

As with nearly every coastal ecosystem found in the United States, man's influence has contributed to the environmental alteration of the estuaries of the East Cote Blanche/Atchafalaya/Four League Bay system. This alteration of natural processes may be the precursor to a decrease in overall water quality, biological productivity, esthetics, and various resources of the coastal region. An attempt to understand the synergistic effects of many of these alterations on coastal ecosystems has only recently begun.

In an effort to put the impacts of shell dredging, regardless of magnitude, into a proper perspective, the decision-maker must also be informed of some of the other activities in the project area. Some of the numerous man-induced alterations to the coastal region and in the immediately adjacent waters of the project area are discussed below.

3.8.1. Sewage Introduced into the Bays

Inadequately treated and raw domestic wastes are discharged into tributary streams and bayous and marsh areas contiguous to the Four League/Atchafalaya/East Cote Blanche Bay system. Raw sewage by-passes and overflows from municipal wastewater treatment facilities, and septic

tank drainage from unsewered communities have all been cited as particular problems. Although these sanitary wastewaters eventually flow into the bay areas, generally the open bays are little affected by these discharges.

Water quality problems, which appear to result principally from sanitary waste discharges, are aggravated by the poorly or untreated seasonal discharges of local menhaden processing, sugar milling, and shrimp processing and packing operations. Water quality is also negatively impacted by the many activities associated with oil and gas exploration and production in the coastal marshes.

3.8.2. Urban and Agricultural Runoff

Houma and Morgan City are the two largest urban centers near the bays, with numerous small communities located in the general vicinity. Urban runoff from these areas impacts local marshes much more severely than the more distant bays. Heavy rains increase occurrences of sanitary wastewater by-passing at sewage treatment plants and overflow of oxidation ponds. Poor quality drainage from unsewered individual residences, camps, and communities can be transported greater distances by stormwater runoff and thus negatively impact larger areas than would otherwise be affected. Although heavy rainfall enhances pollutant transport, the pollutant concentrations are diminished. A proportionate dimunition of impacts likely occurs also. Intervening marshes between the urban areas and the bays effectively absorb much of the impact of urban runoff.

Runoff from agricultural lands result in the deposition of fertilizers and pesticides in local marshes. The impact of nitrogen and phosphorus in the runoff to local marshes and the bays, while not desirable, is probably not severe. Few of the highly toxic and persistent organochlorine insecticides are still in use. The currently favored organophosphorus and carbamate pesticides are not persistent in the environment; they are, however, highly toxic to fish and wildlife. Fish

kills attributable to these pesticides normally affect relatively small areas and typically occur very soon after the pesticide application. As is the case with urban runoff, local marshes are most likely more heavily impacted by agricultural runoff than are the more distant bays.

3.8.3. **Impacts of Shrimping**

Comparatively few studies have been accomplished which examine the impacts of the use of large trawls on the bottom fauna in shallow embayments, such as those of the project area. However, common sense dictates that the effect of dragging a heavily weighted trawl, that may be up to 15 m across the mouth, through the soft, unconsolidated bottoms at 3-8 knots probably has a considerable impact on the benthic and epibenthic animals. The fact that this method is effective in the capture of often-buried fish and invertebrates leads one to conclude that it does greatly disturb the bottom, and the associated benthos. The total or cumulative effect of this type of operation depends heavily on a number of factors, including the number of active commercial and sport trawling boats, salinity patterns, wind and wave patterns, and the concentrations of fish and invertebrates in the area.

It is well known and easily observed from aerial photography that turbidity levels are elevated as a result of the bottom disturbance created by passage of the trawl. The areal extent of the increased turbidities can vary greatly depending on the numbers of shrimping vessels and the sizes of the trawls and boards (doors) of the trawls. The larger trawls obviously disturb a greater width of water bottoms and the heavier trawl boards penetrate deeper into sediments. Increased turbidities as a result of shrimping are greatest during the first few weeks of shrimping seasons when large numbers of commercial and recreational shrimpers trawl extensively. Little is known concerning the alteration of bottom sediments as a result of shrimping, however it is known that extensive areas of the bottom are disturbed by this activity. Schubel et al., (1979) investigated shrimping as a source of suspended sediment in Corpus Christi Bay, Texas, and showed that sediment

disturbance in the bay, as a result of shrimp trawling, was 10-100 times greater than that caused by maintenance of navigation channels. Maximum concentrations of suspended sediments measured in the plumes of shrimp boats were comparable to those in the plumes from dredges operating in the same area.

Bottom trawling for shrimp also destroys vast numbers of fish and invertebrates which are incidentally captured along with the shrimp (by-catch). With the exception of a few other desirable species (e.g., flounder, seatrout, blue crab, etc.), these other organisms, nearly always dead, are discarded back into the water. The ratio of by-catch to shrimp varies considerably depending on the time of the time of the year and the area in which the shrimping is conducted, but the by-catch is often considerable. Shrimping efforts are most heavily concentrated during the first few weeks of brown shrimp season (usually in May), when large numbers of estuarine-dependent species utilize the estuaries as a nursery area. It is probable that shrimping serves to reduce populations of some of these species. On the other hand, it is believed by some that the discarded organisms ultimately contribute to the overall productivity of the system.

3.8.4. Impacts of Other Permitted Activities

A great many activities of a construction nature occur in the coastal waters of the State of Louisiana, many of which require permits from the US Army Corps of Engineers (USACE) or other regulatory agencies charged with the protection of the state's natural resources. All of these activities exert certain impacts on the system in which they are constructed, even though the impacts are often short term and localized. A review of the files of the New Orleans District has generated the following list of activities permitted by the USACE which occur in the project area or adjacent waters, the impacts of which are discussed below.

Type of Activity	Number
Oil Canals, Channels and Slips with Structures	385
Pipelines	238
Oil Structures	158
Mooring Facilities (Marinas, Wharves, etc.)	36
Miscellaneous Structures	34
Submarine/Aerial Cable Crossings	23
Dredging, Bulkheads, and Fill	18
Dredging Projects	14
Fill Projects	11
Oil Ring Levees, Board Roads	10
Bulkheads and Fill	8
Canal Plugs and Closures	8
Bulkheads	6
Dredge and Fill Activities	4
Boat Slips	3
Levees	3
Marsh Management Programs	2

In the coastal regions of Louisiana, one of the primary causative agents in the alteration of the estuarine system and associated wetlands is the proliferation of canals. A great deal of work has been conducted on the impact of the numerous canals in the wetlands of Louisiana, much of which has been summarized by Turner (1983). Impacts most often attributed to the construction of canals and the associated spoil mounds are disruption of wetland hydrologic characteristics (both above and below the marsh surface), saltwater intrusion (which accelerates marsh losses), quickened freshwater runoff, altered sediment depostion patterns, significant land loss (due to widening of canals by erosion), and modification of nutrient supplies to adjacent wetland areas. In general, the impact of the continual construction of canals in

the coastal wetlands is the acceleration of the deterioration of marsh. This conversion of areas with high biological productivity, important hydrologic function, and significant geological values has considerable implications. These canals indirectly lead to increased land loss, and overall decreases in water quality, storm buffering capacity, biological productivity, and loss of revenue.

Bulkheads, wharves, mooring facilities, boat slips, and similar structures cause several types of impacts. During construction, turbidity, depressed dissolved oxygen levels, marsh filling, and other associated impacts often occur. Such structures can provide substrate for attachment of certain organisms; however, if they are constructed of treated materials, the potential exists for problems related to chemical contaminants. Depending on the size, location, and orientation of these structures, hydrological regimes can be altered.

Filling activities often destroy valuable wetland habitats. In addition to the direct habitat losses, the loss of wetlands causes decreased productivity in adjacent waterbodies. Subsequent development of filled areas often leads to a variety of secondary impacts.

Dredging activities cause a variety of primary and secondary impacts, often with direct habitat losses occurring. If the dredging is conducted in wetlands, valuable marsh habitats may be converted to relatively low-value open water areas. If the dredging is conducted on existing waterbottoms, there is a direct loss of benthic habitat and organisms. Turbidity, reduced dissolved oxygen concentrations, and release of nutrients and contaminants from the sediments often result from dredgings and impacts vary with the magnitude of the dredging. Dredging of canals and channels often causes serious saltwater intrusion and increased erosion.

Construction of marinas often impacts large areas of wetlands and also causes the same short-term, localized impacts typical of other construction activities. A variety of secondary water quality impacts

can also occur due to leakage of oil and gas from the vessels and from toxic substances both in the constuction materials and in marine, antifouling paints used on the bottoms of the boats. Other amenities associated with large marinas also contribute to water quality problems.

Levees are one of the most damaging of man's activities. In addition to direct habitat losses due to construction, levees disrupt sheet flow and alter hydrological regimes. Due to their weight, they also often affect flow of water beneath the marsh surface. It has been well documented that marsh losses are very high adjacent to levees.

Submarine cables and pipelines destroy benthic habitat and cause localized impacts similar to those described above under dredging impacts. In some cases, these impacts occur periodically due to maintenance activities. These pipelines also present potential safety hazards and potential hazards to the environment in the event that they are ruptured.

Oil and gas exploration activities cause a variety of impacts. Impacts of canals and pipelines have been discussed above. Construction of platforms and tank batteries in the open waters destroys benthic habitat and causes turbidity and associated impacts. Salinities in the vicinity of tank batteries are sometimes elevated due to the higher salinity of formation waters. One of the most significant potential impacts of oil exploration and resultant structures is the possibility of a serious oil spill which could have grave biological implications.

3.8.5. **Impacts of Corps of Engineers Civil Works Projects**

The USACE is responsible for the construction and maintenance of many projects designed to improve and maintain navigable waterways, and to provide flood and hurricane protection. The environmental aspects of these actions have been considered under other EIS's and are included here to give perspective of the currently authorized Federal projects.

Maintenance of Navigable Waterways

The Atchafalaya River and Bayous Chene, Boeuf, and Black project is located in the coastal area of southcentral Louisiana. The purpose of the project is to enlarge existing navigation channels sufficiently to permit the passage of large offshore drilling rigs and related marine equipment between construction and repair facilities on Bayous Boeuf and Black, and drilling sites in the Gulf of Mexico. The navigation channel is 20 by 400 feet, starting from the vicinity of the US Highway 90 crossing over Bayou Boeuf and via several inland waterways, across Atchafalaya Bay to the 20-foot depth contour in the Gulf of Mexico. Material dredged from Atchafalaya Bay would be deposited in open water west and east of the channel and the material in the Gulf of Mexico deposited east of the channel. It is the intent to conduct disposal of dredged material in the Atchafalaya Bay to encourage marsh development whenever possible. The Atchafalaya Bay reach presently requires annual maintenance dredging, but it is hoped that by 1990 channelization in the delta will occur, causing the channel to scour. Maintenance dredging in the gulf reach is expected to be required annually over the 50 year life of the project. Construction of the project was completed in September 1981.

The following impacts of the Chene, Boeuf, and Black project have been taken from the final Environmental Impact Statement dated March 1973and the supplement to that Environmental Impact Statement dated November 1976. A small portion of the reef and shell deposits within the Atchafalaya Bay would temporarily be contaminated by fine-grained sediments during dredging operations. It is anticipated that disposal of dredged material would not significantly affect the overall quality of the receiving waters. The sedimentary processes and the continual buildup of the delta would not be endangered. Several hundred acres of Atchafalaya Bay bottom would be converted to ridge and fresh marsh by deposition of the dredged material.

Loss of bay bottom may result in loss of nursery ground for fishery species. Oyster and other benthic organisms in the vicinity would be covered with sediment carried from construction and maintenance activities. Temporary turbidity increases would not be sufficient to violate established water quality standards. Increased turbidity would have a minor adverse effect on any sport and commercial fishing in the immediate area.

In October 1977, the New Orleans District Corps of Engineers published a report which documented and analyzed the results of a water quality monitoring program conducted to obtain data prior to any dredging operations in the Atchafalaya Basin Floodway System. Soil chemistry and water quality analyses were performed on native water and bottom samples in the Atchafalaya Bay to determine what effects dredging would have on water quality. The results of the study indicated that there would be no release of any of the pollutants of interest from the dredged material to the receiving water.

Because accelerated growth of the delta in Atchafalaya Bay will adversely affect navigation and flood-carrying capacities of the Atchafalaya Basin Floodway system, the USACE is preparing a feasibility report/EIS that will examine delta development alternatives.

Any alternative(s) considered must maximize delta formation while maintaining existing flowlines and providing for navigation. One alternative to be considered would involve the placement of dredged material on both sides of the existing navigation channel to maintain flow at a level that would insure it remains a self-scouring channel. Flows in excess of the amount needed for maintenance of the navigation channel would be forced to exit into the developing delta via existing bifurcation channels, thereby enhancing delta development. Additional alternatives to be considered in the feasibility report will be developed as part of a coordinated effort involving USACE, USFWS, LDWF, Environmental Protection Agency, and LSU Center for Wetland Resources. According to the current study schedule, the draft feasibility report/EIS

should be completed in May, 1988, with the final report available one year later.

Maintenance dredging in the Atchafalaya Bay averaged 4.5 million cubic yards and ranged from 1.1 to 17.8 million cubic yards per event from 1976 to 1985. In the Gulf of Mexico reaches it averaged 5.5 million cubic yards annually for the same period.

Flood Control Activities

The Atchafalaya Basin Floodway system, a prominent feature of the Mississippi River and Tributaries project, extends from the proximity of Old River, at the junction of the Red and Mississippi Rivers, to the Gulf of Mexico (USACE).

Lower Atchafalaya River and Wax Lake Outlet are the outlets for the floodway system. Wax Lake Outlet was constructed to improve the capability of the Atchafalaya Basin Floodway system to pass floodflows to the Gulf of Mexico.

The Atchafalaya Basin Floodway system project is the primary factor in shaping the present and future physiography of the Atchafalaya Bay. The project controls the amount of flow and sediment entering the system and where the flow and sediment can go. By controlling these two parameters, the project exerts influence on salinity and other water quality parameters, delta development, habitat development, and other environmental features of the bays.

The USACE is conducting a reevaluation study of the authorized East Atchafalaya Basin Protection Levee (Avoca Island Levee) feature of the Atchafalaya Basin Floodway system project. The purpose of this study is to evaluate possible solutions to backwater flooding problems in the Morgan City, Louisiana, vicinity that are directly related to operation of the Atchafalaya Basin Floodway. Both structural and nonstructural alternatives to flood control are being considered. The Avoca Island

Levee Extension Alternative(s) consist of extending the existing Avoca Island Levee, incrementally, to maintain 1950 backwater conditions east of the floodway. One of the three levee extension alignments being evaluated, the adjacent-to-channel alignment, would extend through Atchafalaya Bay, paralleling the eastern side of the Atchafalaya Bay navigation channel. Extension of the levee along this alignment would result in the eventual loss of the eastern half of the developing delta directly by levee alternative(s), consisting of a barrier levee and pumping system that would be either parallel to the new U. S. Highway 90 being built from Houma to Morgan City, or parallel to Bayou Black from Gibson to Houma. According to the current study schedule, the draft reevaluation report/EIS should be completed in late 1987, with the final report to follow one year later.

SUMMARY

The cumulative impacts which affect the project area are all those detailed in the analysis of shell dredging, as well as those listed above.

4. LIST OF PREPARERS

The following people were primarily responsible for preparing this Environmental Impact Statement.

Name	Discipline/Expertise	Experience	Role in Preparing EIS
Mr. Gary D. Goeke	Fisheries Biology	1978, B.S., Marine Biology, Univ. South Alabama; 1980, M.S., Marine Biology, Univ. South Alabama 4 years, Marine Biologist, Barry A. Vittor and Associates, Mobile, AL; 3 years, Marine Biologist, Gulf Coast Research Laboratory, Ocean Springs, MS; 2 years, Environmental Studies, Corps of Engineers, New Orleans District	EIS Coordinator (Planning Division), Effects on Aquatic Resources and Wildlife
Mr. Dennis L. Chew	Fisheries Biology/Management	1970, B.S., Marine Biology, Auburn University; 1975, M.S., Biological Sciences, Univ. Southern Mississippi, Gulf Coast Research Laboratory 4 years, Marine Biologist, Gulf Coast Research Laboratory, Ocean Springs, MS: 2 years, Assistant to the Director, Mississippi Marine Conservation Commission, Biloxi, MS; 7 years, Environmental Studies, Corps of Engineers, New Orleans District	Assistant EIS Coordinator (Planning Division)
Ms. Diane E. Ashton	Fisheries Biology	1970, B.A., Zoology, Univ. Wisconsin; 1974, M.S., Zoology, Univ. Connecticut 2 years, Associate Ecologist, NUS Corporation, Pittsburgh, PA; 2 years, Research Biologist, Ichthyological Associates, Bordentown and Sayreville, NJ; 2 years, Aquatic Ecologist, Aquatic Ecology Associates, Erie and Pittsburgh, Pa; 5 years, Aquatic Biologist, Michigan State Universty, E. Lansing, MI; 3 months, Environmental Studies, Corps of Engineers, New Orleans District	Biological Assessment on Sea Turtles; Effects of Turbidity on Fish and Invertebrates; Summary of Shell Dredging Regulations and Restrictions

4. LIST OF PREPARERS (Continued)

Name	Discipline/Expertise	Experience	Role in Preparing EIS
Mr. E. Burton Kemp, III	Engineering/Coastal Geology	1956, B.S., Geology, Louisiana State University; Graduate Studies Tulane University; Certified Professional Geologist 1.5 years, Espey, Huston and Associates; 3.0 years, McClelland Engineers; 25 years, Engineering Division/Foundations and Materials/Geology, Corps of Engineers, New Orleans District	EIS Contributor for Coastal Geology, Geomorphology, and Geotechnology
Mr. Paul A. Ross	Geology	1973, B.S., Geology, Murray State University 9 years, Construction Geologist, Corps of Engineers, Nashville District and Middle East Division; 2 years, Engineering Geologist, Corps of Engineers, New Orleans District	Researched Mineral Production and Geomorphic History of Study Area
Mr. Charles Rome	Civil Engineering/Materials	1977, B.S., Civil Engineering, University of New Orleans; 1982, M.S., Civil Engineering, Oklahoma State Unviersity; Professional Engineer 5.5 years, Geotechnical Engineering/Foundations and Materials Branch, Corps of Engineers, New Orleans District; 4 years, Materials Engineering/Foundations and Materials Branch, Corps of Engineers, New Orleans District	Defined Some Shell Uses and Potential Alternate Materials.
Mr. Robert H. Bass	Coastal Engineering	1978, B.S., Geology, Univ. Alabama; 1981, B.S., Civil Engineering, Univ. Alabama. 4 years, Coastal Engineer, Corps of Engineers, New Orleans District	Land Loss and Coastal Erosion in Gulf Coast Area
Mr. Robert H. Cunningham	Physical Geographer	1970, B.S., Geology/Geography, Stephen F. Austin State Univ; 1973, M.S., Physical Geography, Louisiana State Univ. 10 years, Research Associate, Louisiana State University, Center for Wetland Resources; Under Contract to Hydraulics Branch, Corps of Engineers, New Orleans District.	Coastal processes.

4. LIST OF PREPARERS (Continued)

Name	Discipline/Expertise	Experience	Role in Preparing EIS
Mr. Marvin A. Drake (continued)		Engineering, Corps of Engineers, New Orleans District	
Mr. James E. Warren	Civil/ Environmental Engineering	1976, B.S.E.T., Virginia Polytechnic Institute and State University; 1983, M.S.C.E., Civil Engineering, Tulane University; Professional Engineer 9 years, Environmental Studies (Water Quality), Corps of Engineers, New Orleans District	Cumulative Water Quality Impacts
Mr. Rodney F. Mach	Hydraulic Engineer/Water Quality	1979, B.S., Civil Engineering, Southeastern Massachusetts University 7 years, Hydrologic Engineering (Water Quality), Corps of Engineers, New Orleans District	Water Column Water Quality and Sediment Quality
Ms. Nancy J. Powell	Civil Engineering/Atchafalaya Basin Floodway	1978, B.S., Civil Engineering, Virginia Polytechnic Institute and State University; 1986, M.S., Civil Engineering, Tulane University 7.5 years, Hydraulic Engineer, Corps of Engineers, New Orleans District	Effects of Shell Dredgng on Hydraulics and Hydrology (Delta Development)
Mrs. Suzanne R. Hawes	Marsh Ecology/Fisheries	1955, B.A., Botany, Brown Univ. 1957, M.S., Botany, Brown Univ. 15 years, Environmental Studies Corps of Engineers, New Orleans District	Review and Technical Assistance
Mr. Steve F. Finnegan	Landscape Architect/Recreational Planning	1975, B.S., Landscape Architecture, Louisiana State University 10 years, Corps of Engineers, New Orleans District	Effects on Recreational Resources
Mr. James E. Chase	Cultural Resources/Management	1974, B.A., History, Adams State University; 1978, M.A., Anthropology, Colorado State University; Ph.D. Candidate, Anthropology, University of Colorado 20 years Archaeological Experience; 12 years, Cultural Resource Management Experience; 1.5 years, Corps of Engineers, New Orleans District	Effects on Cultural Resources

4. LIST OF PREPARERS (Continued)

Name	Discipline/Expertise	Experience	Role in Preparing EIS
Mr. Timothy J. Lookingbill	Regional Economics	1963, B.S., Business Administration, Univ. of Arkansas 23 years, Economics, Corps of Engineers, New Orleans District	Social and Economic Impacts
Mr. Robert D. Lacy, Jr.	Economics/Socioeconomic Assessment	1968, B.A., History, Alabama College 15 years, Economics, Corps of Engineers, New Orleans District	Socioeconomic Assessment
Mr. Burnell J. Thibodeux	Civil/Hydraulic/Environmental Engineering	1974, B.S., Civil Engineering, Tulane University; 1977, M.S., Tulane University; Professional Engineer 12 years, Hydraulic and Hydrologic Studies, Corps of Engineers, New Orleans District	EIS Coordinator (Engineering Division)
Mr. Marvin A. Drake	Environmental Engineering/Water Quality, Hydrology	1964, B.C.E., Civil Engineering, University of Louisville; 1975, M.S.C.E., Civil Engineering, Tulane University 11 years, Hydrology and Hydraulic Engineering; 6 years, Environmental	Effects on Suspended and Bottom Sediments
Ms. Laura J. Swilley	Environmental Sciences/Biology	1975, B.S., Biology, Univ. Florida; 1976, M.S., Environmental Science, East Tennessee State University 3 years, Environmental Specialist, U.S. Department of Commerce, Atlanta, Georgia; 1 year, Marine Environmental Science, U.S. Coast Guard, Washington, D.C.; 8 years, Environmental Resources Specialist, Regulatory Environmental Assessment, Corps of Engineers, New Orleans District	EIS Coordinator (Operations Division)

5. PUBLIC INVOLVEMENT

5.1. PUBLIC INVOLVEMENT PROGRAM

Two scoping meetings were held to allow interested parties to express their concerns regarding shell dredging and to assist in identification of impacts and alternatives to be addressed in the EIS. The first meeting was held in Morgan City, Louisiana, on June 24, 1986, where the comments of 158 registered attendees were recorded. The second meeting, held in New Orleans, Louisiana, on June 26, 1986, attracted 145 registered attendees, whose comments and concerns were also recorded. Participants were also informed that written comments would be gathered through July 11, 1986. A total of 463 comments were recorded from the scoping meetings and numerous concerns were also submitted in 16 scoping letters. It should be pointed out that comments received at these meetings pertained to both the oyster shell dredging addressed in this EIS as well as the clam shell dredging which is being addressed in a companion EIS. The comments were analyzed and a Scoping Document was prepared and distributed to all scoping meeting participants on August 9, 1986. The comments were carefully reviewed to formulate a list of significant concerns/issues that have been addressed in this EIS. A Notice of Intent to prepare this EIS was published in the Federal Register on July 7, 1986.

As originally intended, the scope of this EIS was to encompass the operations of the applicant in Four League Bay, Atchafalaya Bay, East and West Cote Blanche Bays, Vermilion Bay, and a narrow strip along the gulf coast from Isles Dernieres to south of White Lake. As the EIS study progressed, however, it became evident that the overall public interest would be best served by further subdividing the EIS preparation. In order to more satisfactorily address the environmental, economic, and social impacts of the shell dredging activities in a timely manner, a notice was promulgated that this EIS would address only those impacts in the areas of Four League Bay, Atchafalaya Bay, and East Cote Blanche Bay. Preparation of additional EIS(s) continue as additional data are

gathered. Existing permits will neither be extended nor renewed until an EIS covering the specific area has been filed and the public interest determination process completed. The notice explaining the change in EIS coverage was mailed out on November 5, 1986.

During preparation of this EIS, a number of formal and informal meetings have been held with a variety of interested parties, including personnel from other agencies, universities, consultants, members of the public, and members of the shell dredging industry. Most of these individuals have been involved with the shell dredging issue for some time. At most of these meetings, shell dredging in both the lakes area and the Gulf Coast area were discussed. The meetings were held for two primary reasons. First, to find out if these people had any published or unpublished information that would be of value in preparation of the EIS, and second, to take advantage of their personal knowledge and opinions concerning the impacts of shell dredging in order to develop an overall approach to impact assessment. The following is a list of primary meetings which have been held with individuals knowledgeable regarding shell dredging.

Individual(s)	Affiliation	Date
Dr. Jack Taylor	Taylor Biological Co.	8 Aug 86
Mr. Don Palmore	Dravo Industries	8 Aug 86
Mr. Gerry Bodin	USFWS	27 Aug 86
Dr. Bruce Thompson	LSU - CWR	28 Aug 86
Mr. Mike Schurtz	DEQ	28 Aug 86
Mr. Dugan Sabins	DEQ	28 Aug 86
Mr. John Tarver	LDWF	29 Aug 86

Individual(s) (cont'd)	Affiliation	Date
Mr. Mike Schurtz	DEQ	29 Aug 86
Mr. Dugan Sabins	DEQ	29 Aug 86
Mr. John Demond	DNR - CMS	29 Aug 86
Mr. Darryl Clark	DNR - CMS	29 Aug 86
Mr. Bo Blackmon	DNR - CMS	29 Aug 86
Ms. Barbara Benson	DNR - CMS	29 Aug 86
Dr. Mike Porrier	UNO	2 Sep 86
Dr. Bill Barnett	Loyola	3 Sep 86
Mr. Don Palmore	Dravo Industries	3 Sep 86
Dr. Gary Childers	SLU	8 Sep 86
Dr. Bob Hastings	SLU	8 Sep 86
Mr. Jim Blackburn	Attorney	15 Sep 86
Mr. Harold Schoeffler	Save Our Coast	15 Sep 86
Mr. Alfred Hitter, Jr.	Save Our Coast	15 Sep 86
Mr. Pete Juneau	LDWF	16 Sep 86
Mr. Gerry Bodin	USFWS	16 Sep 86
Dr. Walter Sikora	LSU	19 Sep 86
Dr. Jean Sikora	LSU	19 Sep 86
Dr. Hinton Hoese	USL	16 Oct 86
Dr. Daryl Felder	USL	16 Oct 86
Mr. Michael Osborne	Attorney	4 Dec 86
Mr. Harold Schoeffler	Save Our Coast	4 Dec 86

5.2 REQUIRED COORDINATION

This draft EIS is being furnished to Federal agencies, state agencies, and other interested parties for their review. Circulation of this report is in accord with the required coordination under the National Historic Preservation Act and the National Environmental Policy Act.

5.3 STATEMENT RECIPIENTS

The U.S. Senators and Congressmen, Federal, and state agencies listed below have received copies of the draft EIS and appendixes. All others have received at least a Notice of Availability. Copies of the EIS have also been furnished to the libraries listed below to provide interested parties further opportunity to review the document.

Honorable J. Bennett Johnston

Honorable Lindy (Mrs. Hale) Boggs

Honorable Jerry Huckaby

Honorable Clyde Holloway

Honorable William "Billy" Tauzin

Honorable John Breaux

Honorable James A. Hayes

Honorable Robert L. Livingston

Honorable Richard Baker

Honorable Buddy Roemer

FEDERAL AGENCIES

Department of the Interior, Office of Environmental Project Review

US Environmental Protection Agency, Regional EIS Coordinator, Region VI

US Environmental Protection Agency, Administrator

US Department of Commerce, Joyce M. Wood, Director, Office of Ecology and Conservation

US Department of Commerce, National Oceanic & Atmospheric Administration, National Marine Fisheries Service, Southeast Region

National Marine Fisheries Service, Mr. Donald Moore. Environmental Assessment Branch

US Department of Agriculture, Washington, D.C.

US Department of Agriculture, Southern Region, Regional Forester, Forest Service

US Department of Energy, Director, Office of Environmental Compliance, Washington, D.C.

Federal Emergency Management Administration, Washington, D.C.

Soil Conservation Service, Harold Austin, State Conservationist

US Department of Transportation, Deputy Director for Environmental and Policy Review

Federal Highway Administration, Division Administrator

US Department of Health and Human Services, Washington, D.C.

US Department of Health and Human Services, Atlanta, Georgia, Stephen Margolis, Ph.D.

US Department of Housing and Urban Development, Regional Administrator, Region VI

Advisory Council on Historic Preservation, Washington, D.C.

Advisory Council on Historic Preservation, Golden, CO

STATE AGENCIES

Louisiana Department of Health and Human Resources, Office of Health Services and Environmental Quality

Louisiana Department of Transportation and Development, Office of Public Works, Assistant Secretary

Louisiana Department of Highways, Mr. Vincent Pizzolato, Public Hearings and Environmental Impact Engineer

Louisiana Department of Wildlife and Fisheries, Mr. Maurice B. Watson, Ecological Studies Section

Louisiana Department of Wildlife and Fisheries, Secretary

Louisiana Department of Natural Resources, Office of Environmental Affairs

Louisiana Department of Natural Resources, Division of State Lands, P. O. Box 44396

Louisiana Department of Natural Resources, Coastal Resources Program

Louisiana Department of Commerce, Research Division, Mrs. Nancy P. Jensen

Louisiana Department of Culture, Recreation, and Tourism, State Historic Preservation Officer

Louisiana Department of Culture, Recreation, and Tourism, Office of State Parks

Louisiana Department of Natural Resources, Office of Environmental Affairs

Louisiana Department of Natural Resources, Office of Forestry

Louisiana State Planning Office, Ms. Joy Bartholomew, Policy Planner

Louisiana State University, Center for Wetland Resources, Dr. Jack R. Van Lopik

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Governor's Coastal Protection Task Force, Gerald Bordelon

LIBRARIES

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OTHER INTERESTED PARTIES

Save Our Coast

Environmental Defense Fund

Orleans Audubon Society, Mr. Barry Kohl

Manchac Fisherman's Association

Ecology Center of Louisiana, Inc., J. Vincent, President

Mr. Oliver Houck, Tulane Law School

Mr. Clifford Danby

Regional Representative, National Audubon Society, South Western Regional Office

Field Research Director, National Audubon Society

Thibodaux-Houma Sierra Club, c/o Bob Blair

Delta Chapter, Sierra Club, New Orleans

Mr. Michael Halle

Chappepeela Group Sierra Club (Florida Parishes), c/o Hulin Robert

National Wildlife Federation, Washington, D.C.

Randy P. Lanctot, Executive Director, Louisiana Wildlife Federation

Wildlife Management Institute, South Central Representative, Mr. Murray T. Walton

The Conservation Foundation, Washington, D.C.

James W. Keeton, Trout Unlimited, San Antonio, TX

Natural Resources Defense Council, Inc.

League of Women Voters of the U.S.

Slidell Sportsmen's League

Mr. Donald Landry, President, South Louisiana Environmental Council

Mr. Sidney Rosenthal, Jr., Field Agent, The Fund for Animals, Inc.

Environmental Impact Officer, Jefferson Parish, Louisiana

Captain O.T. Melvin, Larose, Louisiana

John M. Anderson, National Audubon Society, Abbeville, Louisiana

Terrebonne Parish Police Jury, Waterways and Permit Committee

Gulf States Marine Fisheries Commission

Mrs. Roberta A. Scull, Government Documents Department, Library, LSU

Government Documents Division, Earl K. Long Library, UNO

Sea Grant legal Program

Chairman, Environmental Committee, Bonnet Carre' Rod and Gun Club

Lake Pontchartrain Sanitary District

Lafayette Natural History Museum and Planetarium

Mr. J. H. Jones, Professor, Department of Economics and Finance, College of Administration and Business, Louisiana Tech University

Mr. C. C. Lockwood, Wildlife Photographer, Cactus Clyde Productions

Mr. R. W. Collins

Mr. Freddy Trosclair, Jr.

Mr. Joel D. Patterson, Manager, Environmental Affairs Section, Middle South Services, Inc.

Mr. Ronnie W. Duke, T. Baker Smith & Son, Inc.

Mr. Warren Mermilliod, Marine Advisory Agent, Louisiana Cooperative Extension Service, U.S. Department of Agriculture, LSU

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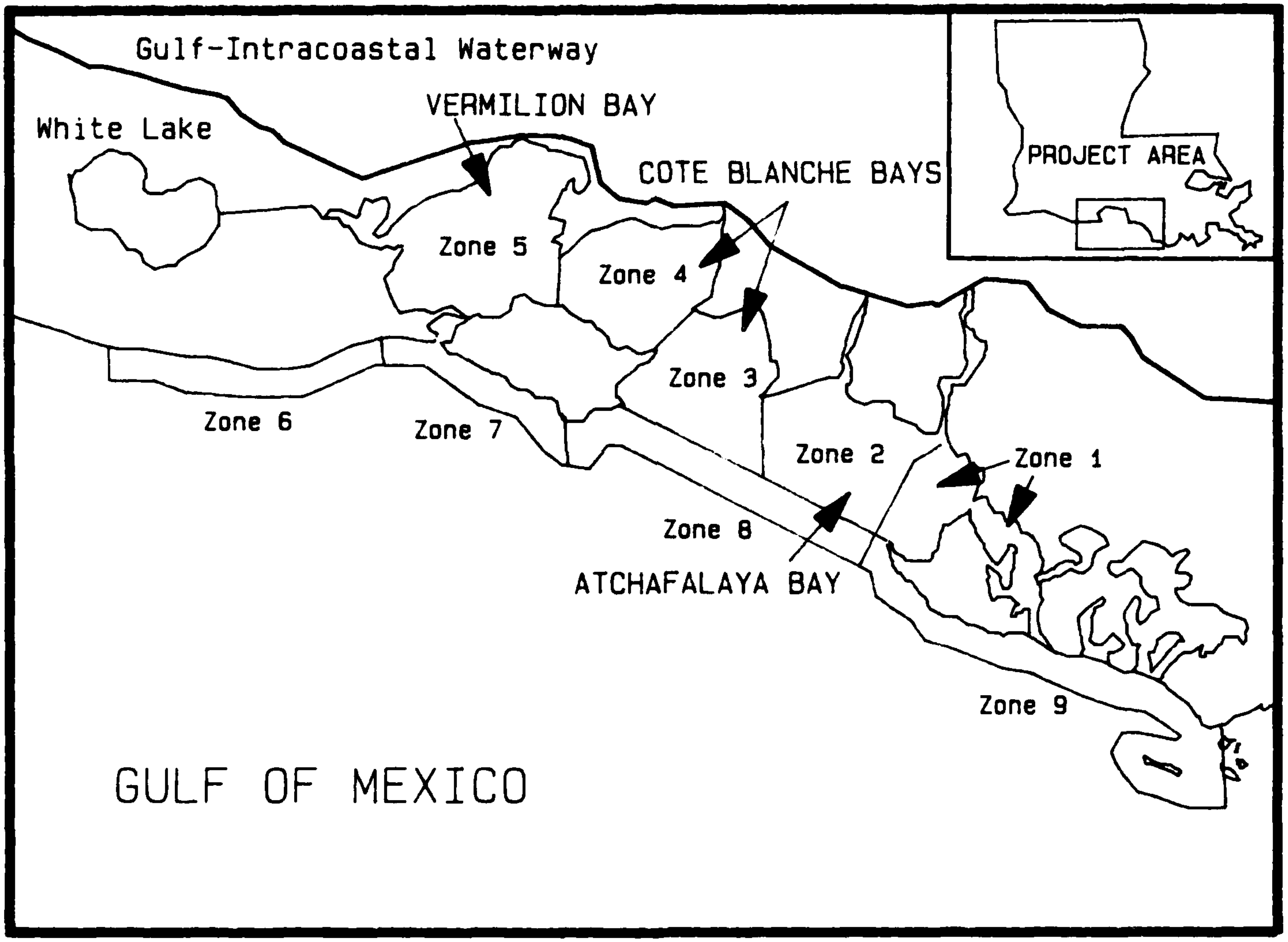

Figure EIS-1. General Vicinity Map.

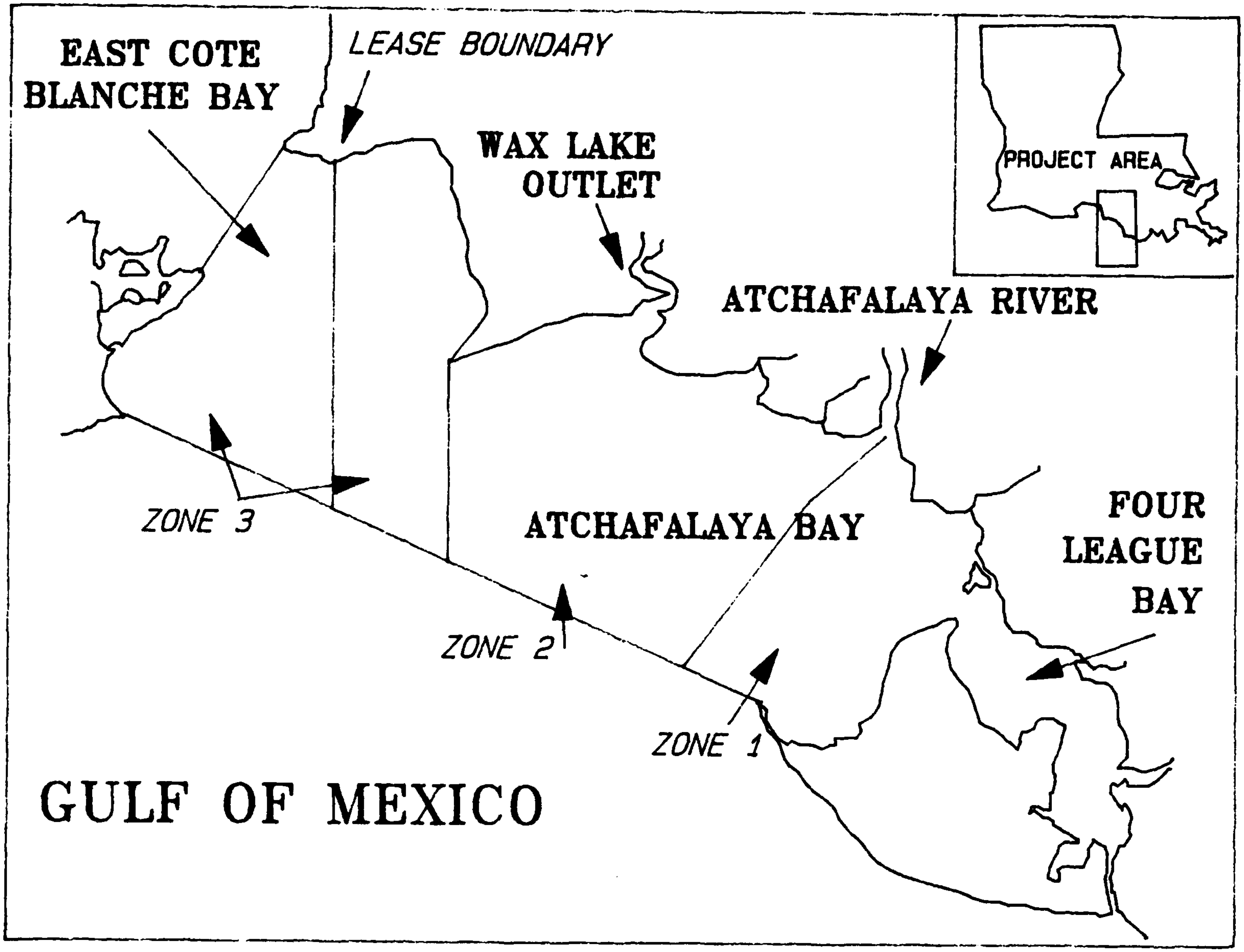

Figure EIS-2. Project Area with Zones and Lease Boundaries Indicated.

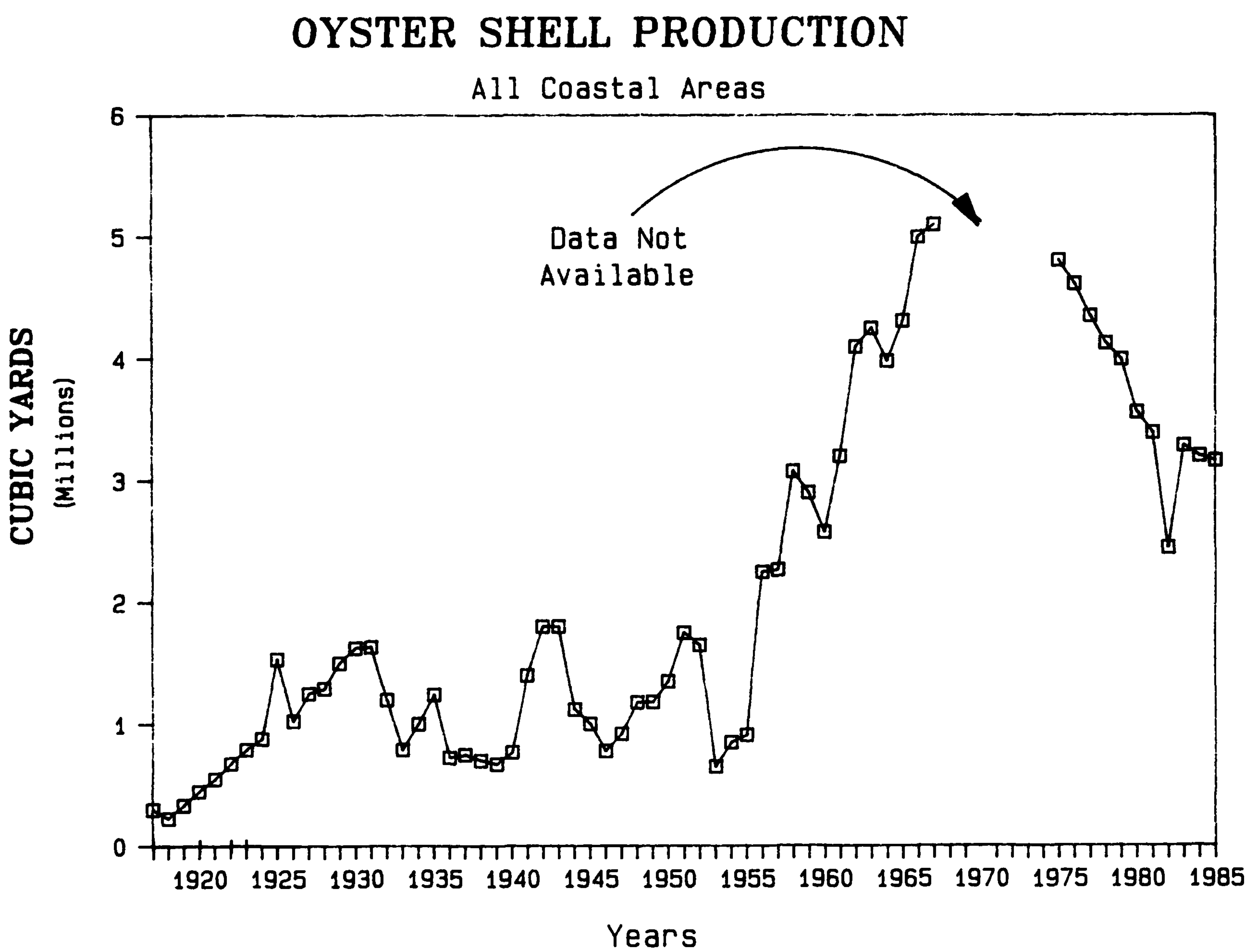

Figure EIS-3. Oyster Shell Production in all Coastal Areas Since 1917.

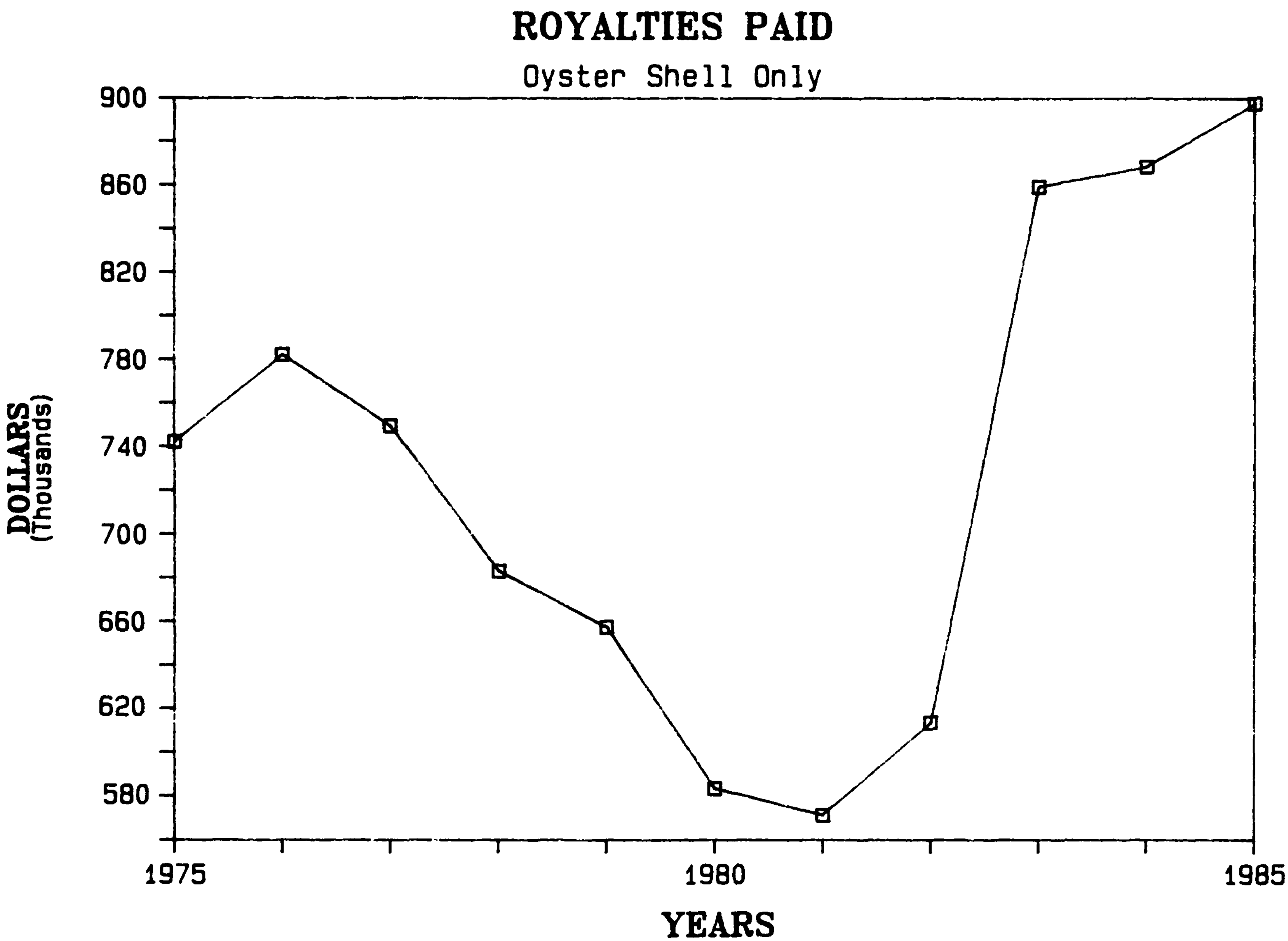

Figure EIS-4. Royalties Paid by Shell Dredgers from 1975-1985

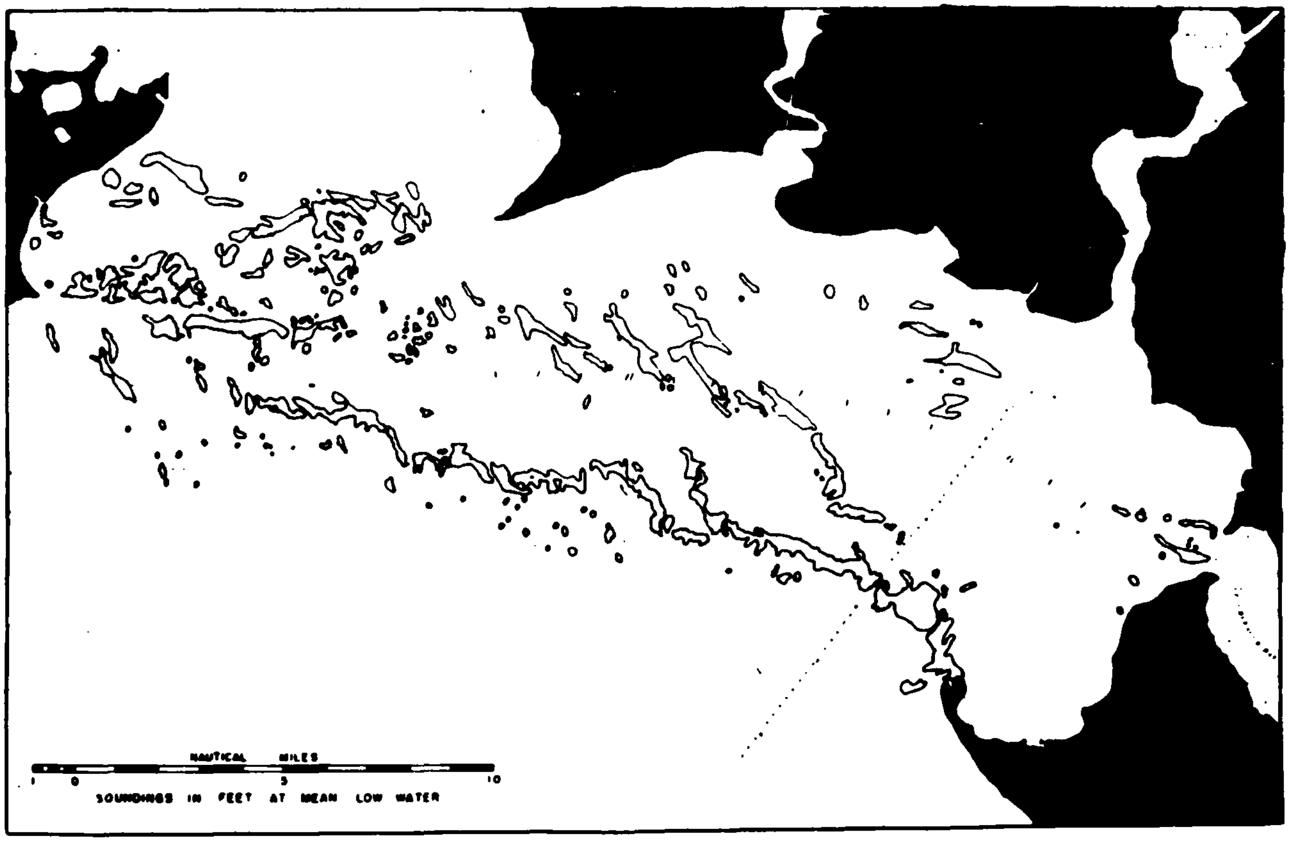

Figure EIS-5. Location of shell reefs (open areas) as shown by Thompson (1953).

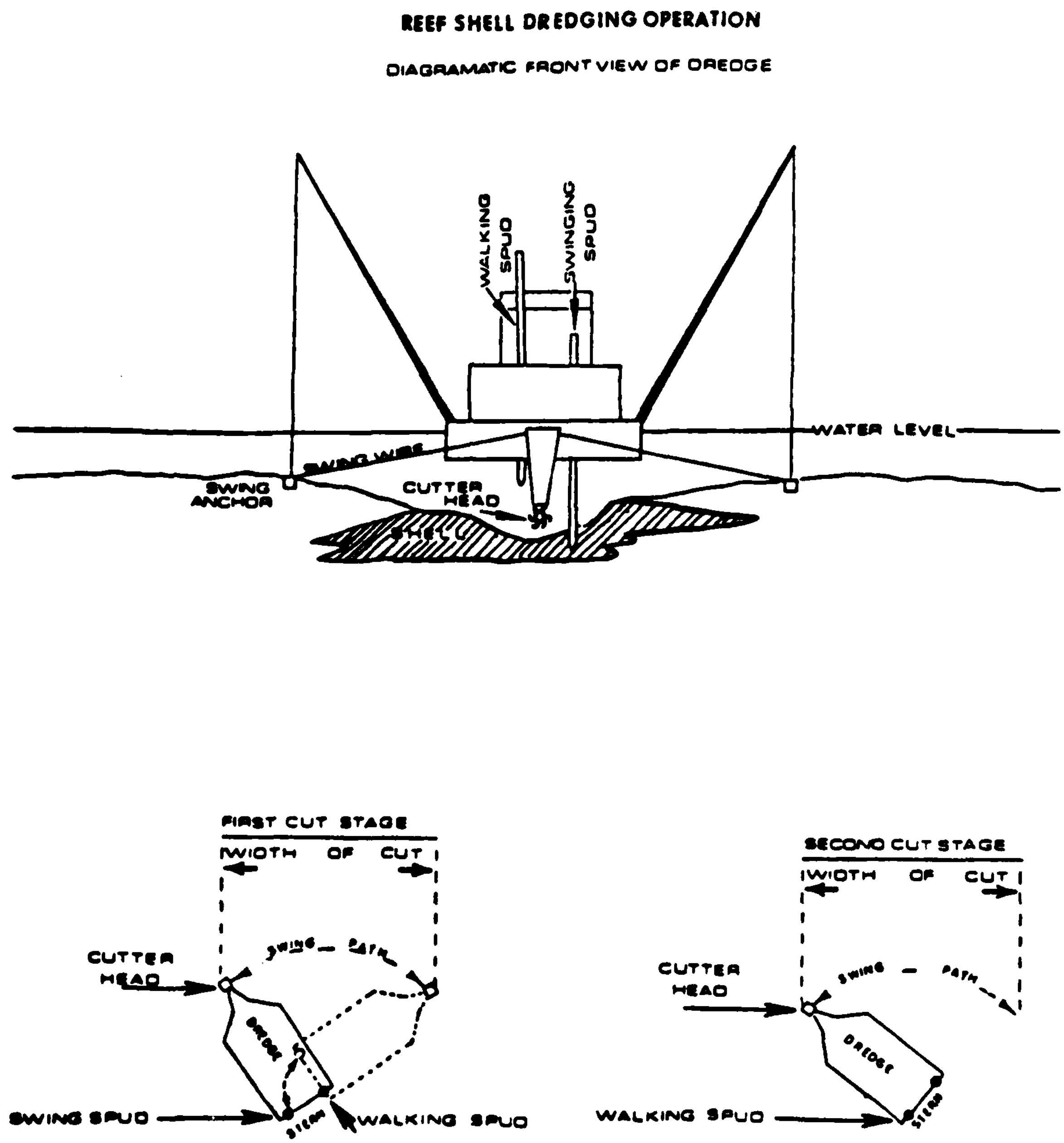

Figure EIS-6. Diagram of operating shell dredge and method of operation.

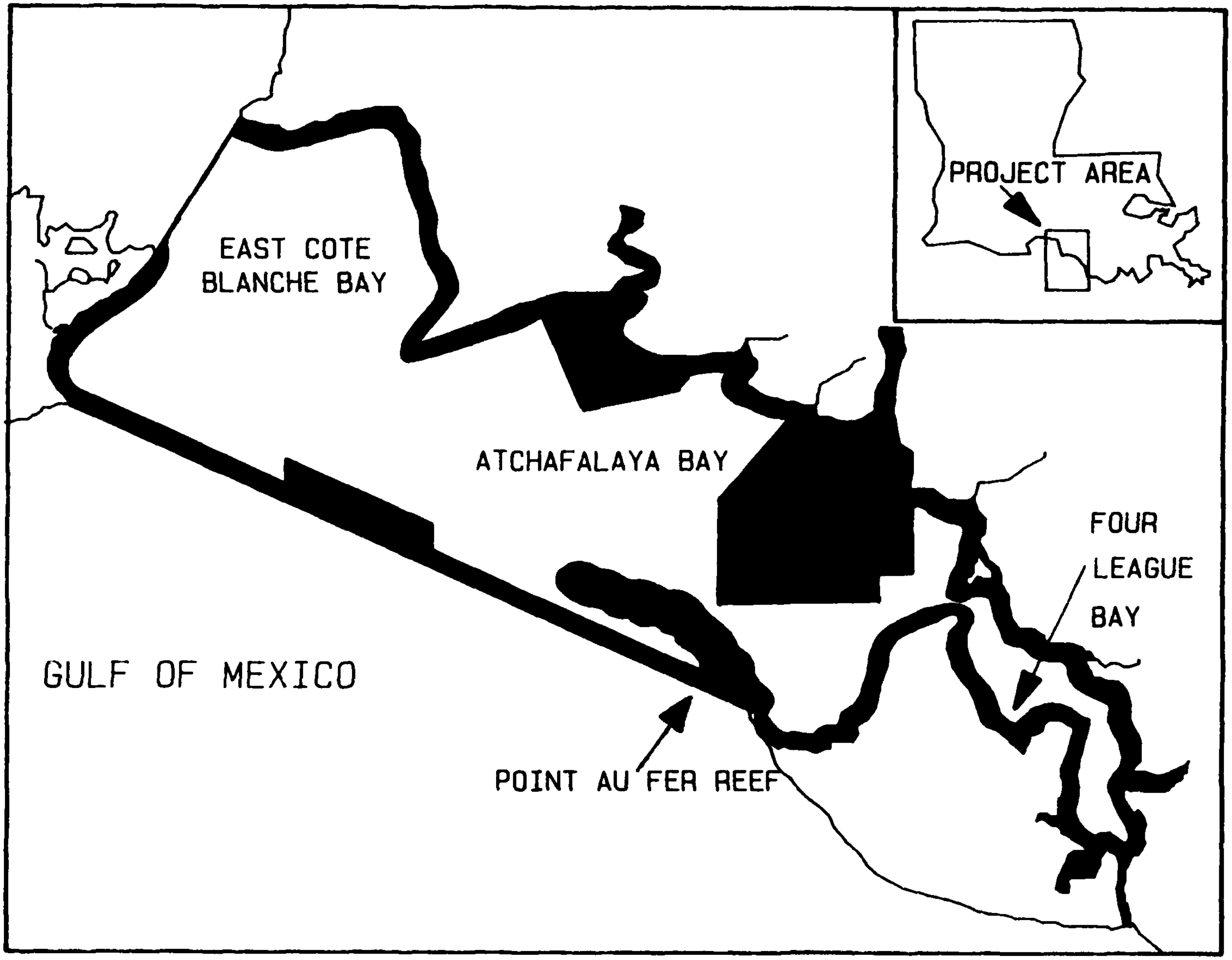

Figure EIS-7. Project Area with Restrictive Zones Indicated.

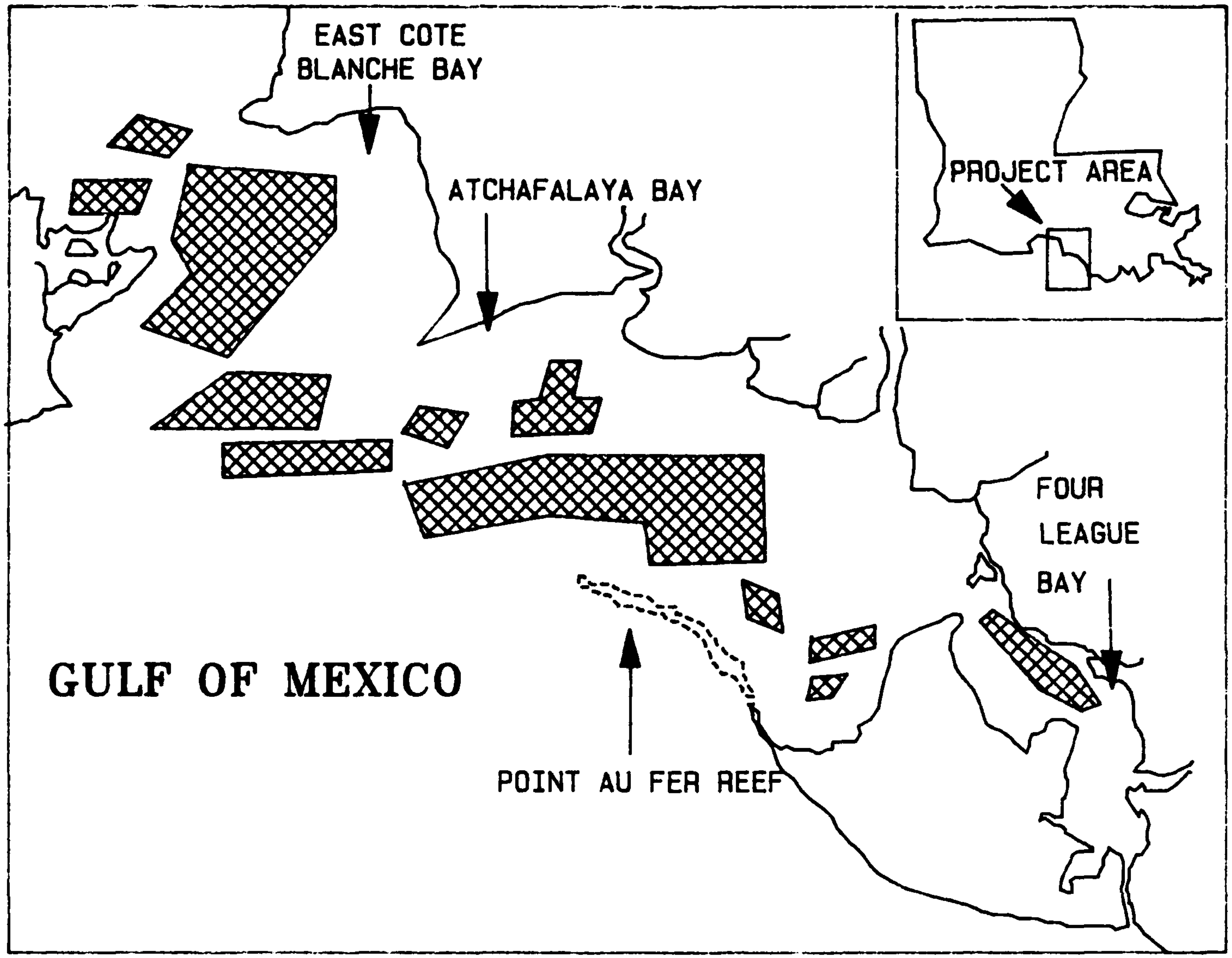

Figure EIS-8. Areas of Known Reserves Identified by Shell Dredging Industry.

APPENDIX A

THREATENED AND ENDANGERED SPECIES

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APPENDIX A

BIOLOGICAL ASSESSMENT OF IMPACTS OF SHELL DREDGING ON THREATENED AND ENDANGERED SPECIES

Introduction

The appendix includes the Biological Assessment of Threatened and Endangered Species. It also inc-udes copies of correspondence between the U.S. Army Corps of Engineers, New Orleans District, and the U.S. Fish and Wildlife Service, and National Marine Fisheries Service concerning threatened and endangered species present in the areas affected by shell dredging, and the impacts of the activity on these species.

BIOLOGICAL ASSESSMENT OF IMPACTS OF SHELL DREDGING ON THREATENED AND ENDANGERED SPECIES

Atchafalaya, Four League, East Cote Blanche Bays, Louisiana

Introduction

This assessment addresses the threatened and endangered species which may be affected by oyster shell dredging in coastal Louisiana, specifically in Atchafalaya Bay, Four League Bay, and East Cote Blanche Bay.

The oyster shell deposits to be dredged occur in reefs, buried under 1-8 ft of silty clay. The type of dredge used is barge-like in design, with an excavating cutterhead, a suction ladder, a pumping system, and a materials washing and screening plant. Shell recovery is accomplished by hydraulic suction. As the cutterhead digs through the shell deposit, it moves forward by hauling itself in on anchor cables, causing the dredge to swing from side to side, pivoting on one of its spuds. A matrix of mud and shell enters through the cutterhead, and is pumped over a series of sizing screens and rotary washers. As the dredge pivots, the dredged material is directed back into the dredged area. Most of the discharge settles in the area of the slow-moving dredge, and the resulting bottom configuration, following dredging, is a series of troughs and mounds.

Two species of sea turtles have been identified by the National Marine Fisheries Service as species which may be impacted by the proposed activity. Kemp's (Atlantic) ridley (Lepidochelys kempi) is listed as endangered and the loggerhead turtle (Caretta caretta) is listed as threatened under the Endangered Species Act.

Information on sea turtles in coastal Louisiana in general is sparse. However, this assessment is the result of conversations and correspondence with knowledgeable persons as well as a review of published and unpublished literature. Historical and recent occurrence of the Kemp's ridley and the loggerhead turtle in the three coastal Louisiana bays is summarized, and the potential impacts are discussed.

Kemp's Ridley (Lepidochelys kempi)

The major nesting beach of the Kemp's ridley is located at Rancho Nuevo, Mexico, 30 km south of the Rio Grande, with sporadic nesting along the Texas coast. Females arrive in small aggregations known as arribadas from mid- April through August (Rabalais and Rabalais 1980). Population declines of the ridley have been attributed to egg stealing on the localized nesting beach, capture of diurnal nesting females, fishing and accidental capture in shrimp trawls (Fuller 1978, Pritchard and Marquez 1973). Nesting of ridleys in coastal Louisiana is insignificant. However, Hildebrand (1981) mentions that Isle Derniere may have been a

prior to the major hurricane of 1856 which destroyed favorable nesting habitats. Viosca (1961) felt ridleys preferred to nest in the loose sand of the Chandeleur Islands rather than the compacted beaches west of the Mississippi. However, Ogren (1977) observed a small turtle, thought to be a ridley, crawling on the beach of Timbalier Island.

Inshore areas of the Gulf of Mexico appear to be important habitats for the ridley. Members of this genus are characteristically found in waters of low salinity, high turbidity, high organic content, and where shrimp are abundant (Zwinenberg 1977, Hughes 1972). Kemp's ridley in the Gulf of Mexico tends to be concentrated around major river mouths, specifically the Rio Grande and the Mississippi (Frazier 1980). Based on returns of females tagged on the nesting beach, adult ridleys move to major foraging grounds, to the south in the Campeche-Tabasco region and to the north off coastal Louisiana. Adults tagged at Rancho Nuevo were recaptured off coastal Louisiana as well as in Vermilion Bay, and animals have been reported from Vermilion Parish to Terrebonne Parish (Pritchard and Marquez 1973, Chavez 1969, Keiser 1976, Zwinenberg 1977, Dobie et al. 1961). Ridleys are commonly captured by shrimpers off the Texas coast, as well as in heavily trawled areas of the Louisiana and Alabama coast (Pritchard and Marquez 1973, Carr 1980). However, occurrence of young ridleys in shrimp trawls in coastal Louisiana has declined in the past 25 years (Hildebrand 1981). Similarly, ridleys are no longer abundant in coastal Florida (Carr and Carr 1977).

Kemp's ridley has been labeled the "Louisiana turtle" by Hildebrand (1981) and is thought to be the most abundant turtle off the Louisiana coast (Viosca 1961, Gunter 1981). The highly productive white shrimp-portunid crab beds of Louisiana from Marsh Island to the Mississippi Delta are thought to be the major feeding grounds for subadult and adult ridley (Hildebrand 1981). The current patterns in the Gulf of Mexico could aid in transport of individuals, where small turtles swimming offshore until reaching sargassum mats would enter the major clockwise loop current of the western Gulf of Mexico carrying individuals north and east along Texas, Louisiana and subsequent coastal areas (Pritchard and Marquez 1973, Hildebrand 1981).

Although Hildebrand (1983) feels the ridley is not a resident of bays and estuaries, Keiser (1976) suggests that the ridley is the most likely sea turtle to enter Atchafalaya Bay or East Cote Blanche Bay with movements related to or controlled by salinity and food availability. Stomach analysis of specimens collected in shrimp trawls off Louisiana includes crabs (*Callinectes*), gastropods (*Nassarius*), and clams (*Nuculana*, *Corbula*, and probably *Mulinia*) as well as mud balls, indicating feeding near a mud bottom in an estuarine or bay area (Dobie et al. 1961). Although considered primarily carnivorous benthic feeders (Ernst and Barbour 1972), jellyfish have also been reported as part of their diet (Fritts et al. 1983). Presence of fish such as croaker and spotted seatrout in the gut of stranded individuals in Texas may suggest that turtles feed on the by-catch of shrimp trawlers (Landry 1986). In Cedar

Key, Florida, ridleys were commonly captured at the entrance to sloughs and were thought to feed on invertebrates in the shallow tidal flats and channels (Carr and Caldwell 1956). Occurrence of ridleys in bays and estuaries such as Atchafalaya Bay, Four League Bay and East Cote Blanche Bay would not be unexpected since many of their primary food items occur in estuarine and inshore areas with silt bottoms (National Fish and Wildlife Laboratory).

Recent information on sightings and strandings in Louisiana, based on interviews with commercial and recreational shrimpers, fishermen, divers, helicopter pilots, and offshore workers, indicated that ridleys were sighted recently (since 1982) in Atchafalaya Bay, Point au Fer, and near an outlet from Vermilion Bay in the summer and in the outlet of Four League Bay (Oyster Bayou) in the fall (Fuller and Tappan 1986). Historical sightings, prior to 1982, included Four League Bay and the mouth of Four League Bay (Fuller and Tappan 1986).

Loggerhead Turtle (*Caretta caretta*)

The principal nesting range of the loggerhead is from Cape Lookout, North Carolina to Mexico, however the majority (90%) of the reproductive effort in the coastal United States occurs along the south-central coast of Florida (Hildebrand 1981). Nesting in the northern Gulf outside of Florida occurs primarily on the Chandeleur Islands and to a lesser extent on adjacent Ship, Horn, and Petit Bois Islands in Mississippi and Alabama (Ogren 1977). Loggerhead eggs were collected from Grand Isle, Louisiana 50 years ago (Hildebrand 1981). Ogren (1977) reported a historical reproductive assemblage of sea turtles which nested seasonally on remote barrier beaches of eastern Louisiana, Mississippi, and Alabama. This included Bird, Breton, and Chandeleur Islands in Louisiana. Loss or degradation of suitable nesting habitat may be the most important factor affecting the nesting population in Louisiana today (Ogren 1977).

Loggerhead turtles are considered turtles of shallow water, less than 50 m (Rabalais and Rabalais 1980). Juvenile loggerheads are thought to utilize bays and estuaries for feeding, while adults prefer waters less than 50 m deep (Nelson 1986). During aerial surveys of the Gulf of Mexico, the majority (97%) of loggerheads were seen off the east and west coasts of Florida (Fritts 1983). Most were observed near mid-day near the surface, possibly related to surface basking behavior (Nelson 1986). Although low numbers of loggerheads were seen regularly off the coast of Louisiana and Texas, they were 50 times more abundant in Florida than in the western Gulf. The majority of the sightings were in the summer (Fritts *et al*. 1983).

Historical sightings, prior to 1982, indicate loggerheads were seen in Vermilion Bay south of Marsh Island (Fuller and Tappan 1986). Recent

sightings include Four League Bay in the fall and the outlet of Vermilion Bay in the summer. No turtles were sighted from February to April in Louisiana and no strandings of loggerhead have been documented (Fuller and Tappan 1986). Loggerheads will migrate west along shallow coastal waters, as indicated by telemetry data from an individual tagged in the Mississippi Delta moving to Corpus Christi (Solt 1981).

Loggerheads are omnivorous, consuming molluscs, crabs, shrimp, sea urchins, sponges, squid, basket stars, jellyfish, and even mangrove leaves in the shallows (Caldwell et al. 1955, Hendrickson 1980, Nelson 1986). Presence of fish species such as croaker in stomachs of stranded individuals may indicate feeding on the by-catch of shrimp trawling (Landry 1986). They appear to be well adapted for feeding on molluscs with a heavy jay and head (Hendrickson 1980). Caldwell et al. (1955) suggest that the willingness of the loggerhead to consume any type of invertebrate food permits its range to be limited only by cold water. In shallow Florida lagoons, loggerheads were found during the morning and evening, leaving the area during mid-day when temperatures reached 31°C. At dusk, turtles moved to a sleeping site and remained there until morning, possibly in response to changes in light or water temperature (Nelson 1986).

In Texas, loggerheads were frequently observed near offshore oil platforms, natural rock reefs and rock jetties (Rabalais and Rabalais 1980). Oyster fishermen have reported large turtles near oyster reefs in Louisiana (Deborah Fuller, pers. comm.). In Texas, large numbers of stranded turtles were observed in areas where individuals were observed offshore over hard substrates (Rabalais and Rabalais 1980).

Sea turtles in the Gulf of Mexico

The majority of the general information on abundance of sea turtles in the Gulf of Mexico, and in Louisiana in particular, is based on aerial survey sightings and stranding information. Fritts et al. (1983) did not observe any ridleys in the vicinity of Marsh Island or off shore during aerial surveys. It has been suggested that aerial surveys would not provide information on turtles in nearshore Louisiana waters because low densites, behavioral patterns, or water turbidity can reduce effectiveness of aerial observations (Owens 1983, Fritts et al. 1983, Fuller and Tappan 1986). Aerial surveys are limited but are better than stranding data in determining population abundance (Fritts et al. 1983). Stranding and capture records do indicate that Kemp's ridley occurs in Louisiana waters. Shrimp trawling activities have been responsible for most of the captures and possibly many of the strandings (Fritts et al. 1983). Recent strandings of ridleys on Louisiana and Texas beaches may be the result of intense localized shrimping activities, although possible effects of explosives used in removal of oil rigs in the Gulf of Mexico on sea turtles are a topic of present concern (O'Byrne 1986). With loggerhead turtles in Georgia, Texas, and North Carolina, highest incidence of strandings paralleled periods of increased trawling activities in nearshore waters also (Crouse 1985, Rabalais and Rabalais

1980, Hillestad et al. 1986, Ogren 1977). Comparison of aerial survey data and stranding data in the Gulf of Mexico is limited in value for estimates of local abundance because numbers stranded reflects intensity of trawling rather than actual abundance (Fritts et al. 1983). In addition, differences in sampling effort and presence of longshore and nearshore currents may account for localized differences in strandings (Hillestad et al. 1978). In Louisiana, the coastal areas are less accessible and probably less utilized by humans so that stranded animals may go unnoticed (Fritts et al. 1983). Efforts to increase information on strandings in Louisiana have intensified and several individuals now routinely patrol several areas of the Louisiana coastline and supply any information found to the Sea Turtle Stranding Network (STSN) (S. Rabalais, pers. comm.).

It has been suggested that ridleys and loggerhead may burrow in estuarine mud along the gulf coast during the winter when water tempertures are too low for normal activity, and remain buried in the mud until warmer weather. Observations of turtle fishermen at Cedar Key, Florida, noted their absence in winter and reappearance in the spring covered with mud (Pritchard and Marquez 1973), although not all turtles are mudcovered suggesting that not all individuals are buried in the mud (Carr et al. 1980). The winter capture of torpid loggerheads and fewer ridleys in the Port Canaveral Ship Channel off eastern Florida (Joyce 1981), as well as torpid individuals by Carr et al. (1980) strongly suggests that the animals may be hibernating in the soft bottom sediments and walls of the ship channel.

There is no information on whether or not turtles do bury themselves in the coastal bays of Louisiana.

Impact of Shell Dredging on Sea Turtles

During the warm months of the year when ridleys and loggerheads are active, it is not expected that shell dredging will have any direct impact on any turtles should they occur in the area. The relative show progress of a dredge in an area, along with associated noise and water disturbance forewarns such motile creatures which would then be expected to escape impingement.

There is no evidence of hibernation of sea turtles in Louisiana, however any turtle occurring in Atchafalaya Bay, Four League Bay, or East Cote Blanche Bay would likely only be affected by dredging operations during the cooler months when turtles might be buried in the silty sediments. If torpid, similar to the situation in Florida, they would be unable to escape either destruction by the cutterhead or capture by the hydraulic suction.

No turtles have been seen during shell dredging operations in this area (D. Palmore, pers. comm.). The physical nature of the dredging operation where the rotary cutterhead cuts out an area before hydraulic suction moves the material onto the dredge, may result in destruction and fragmentation of any individuals in the direct path of the cutterhead

however. If any individuals have been entrained in the past, they may or may not have been observed depending on the vigilance of an observer and/or the nature of the turtle fragments, if any, transported onto the dredge.

Occurrence of ridleys or loggerheads in the bottom sediments of any previously dredged areas, either dredged for shell resources or for maintenance dredging of the navigation channel in the area is unknown. The possibility exists that the dredged sediments re-deposited in an area following passage of a shell dredge as well as altered bottom configuration may be attractive to turtles foı hibernation and could draw animals to an otherwise less attractive area. However, little information exists on the actual frequency of occurrence of sea turtles burying in the sediments in the Gulf of Mexico. Although several theories exist as to why the Canaveral Ship Channel off Florida harbors large concentrations of loggerheads, no information is available on what features are suitable for hibernation.

Methods to Reduce Impacts of Shell Dredging on Sea Turtles

If it were determined that Kemp's ridleys or loggerheads were indeed hibernating in the areas to be dredged, methods available to protect turtles are somewhat limited. Attempts could be made to physically remove turtles from an area in a manner similar to that used in Florida where the area to be dredged was trawled prior to dredging and captured individuals were released away from the area. Such release may be ineffective; however, if water temperatures are low enough to produce torpor, they are too low to permit turtles to re-bury themselves.

Certain types of draghead dredges, which function by hydraulic erosion, can be modified with cages or deflector systems to prevent turtle entrainment (Joyce 1982). Present use of the California type draghead has significantly reduced the capture of loggerhead turtles in Florida. This modification was the result of findings of an interagency task force formed to investigate methods for reducing the incidental injuring and/or killing of endangered and threatened turtles in connection with hopper dredging in federal navigation channels (Joyce 1981) (Sea Turtle/Dredging Task Force). In addition to the modified draghead, the overflow is monitored using large mesh baskets designed to retain any turtles or turtle fragments (P. Schmidt, pers. comm.). Owing to the nature of the material being dredged in Louisiana, installation of such a collection basket on a shell dredge would probably not provide any additional information on the presence of sea turtles because of the highly efficient destructive nature of the cutterhead. Replacement of the cutterhead with another type of dredge head would not be feasible owing to the compact reef nature of the oyster shells and methods required for harvest of the resource.

Aside from physical modification of the existing dredge equipment, dredging only during non-threatening times of the year is another alternative to reduce impact on sea turtles. If turtles are hibernating in the area, the period of hibernation would be when they are most

vulnerable. Prohibiting dredging in these areas during times of the year when water temperatures are less than 15°C (Mrosovsky 1980), could eliminate any encounters with animals that would be hibernating under these temperature regimes. The time of year when water temperatures in Atchafalaya Bay and East Cote Blanche Bay would be expected to be less than 15°C occurs from December to February. This is based on temperatures from a U.S.G.S. gauging station on the lower Atchafalaya River at Morgan City as well as temperature data collected in Atchafalaya Bay and East Cote Blanche Bay (Juneau 1975, Deegan 1985).

Conclusions

1. Kemp's ridley and loggerhead turtles may occur in Atchafalaya Bay, Four League Bay and East Cote Blanche Bay, based on historical and recent sighting information. All sightings were during the summer and fall.

2. No sea turtles have been observed during any past shell dredging operations in this region.

3. Sea turtles would be expected to avoid the slow-moving dredge during the majority of the year (March through November).

4. There is no evidence of hibernation of sea turtles in Atchafalaya Bay, Four League Bay, or East Cote Blanche Bay.

5. Hibernating sea turtles, if present, would occur when water temperatures were 15°C or less, generally during the period from December through February in coastal bays of Louisiana. Hibernating individuals may be subject to damage or destruction by a cutterhead dredge.

6. Based on present information, the impact of shell dredging on Kemp's ridley and loggerhead turtles in coastal bays of Louisiana is thought to be negligible.

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JUN 18 1986

Planning Division
Environmental Analysis Branch

June 18, 1986

Mr. Dennis B. Jordan
Field Supervisor
U.S. Fish and Wildlife Service
Jackson Mall Office Center
300 Woodrow Wilson Avenue, Suite 3185
Jackson, Mississippi 39213

Dear Mr. Jordan:

We are requesting information concerning listed and proposed threatened and/or endangered species which may be impacted by extension of Section 10 and Section 404 permits to dredge shells in the Gulf Coast Area (GCA). The GCA consists of Vermilion Bay, West and East Cote Blanche Bays, Atchafalaya Bay, Four League Bay, and a narrow margin along the shore of the Gulf of Mexico (Figure 1). Although clam shells (Rangia) occur in the GCA, only oyster shells are currently dredged.

The oyster shell deposits are found in reefs, with millions of cubic yards of shell more or less cemented together. The fossil shells are buried under 4 to 8 feet of silty clay. These accumulations of fossil shells are dredged as a local source of calcium carbonate and aggregate. The type of dredge used is barge-like in design, with an excavating cutterhead, a suction ladder, a pumping system, and a materials washing and screening plant. Shell recovery is accomplished by hydraulic suction. As the cutterhead digs through the shell deposit, it moves forward by hauling in on anchor cables, causing the dredge to swing from side to side, pivoting on one of its spuds. A matrix of mud and shell enters through the cutterhead, and is pumped over a series of sizing screens and rotary washers. As the dredge pivots, the dredged material is directed back into the dredge area through a submerged discharge pipe. Most of the discharge resettles in the area of the slow-moving dredge, and the resulting bottom configuration, just after dredging, is a series of shallow troughs and mounds.

The oyster shells are used in the manufacture of cement, glass, chemicals, pharmaceuticals, wallboard, chicken and cattle feed, and agricultural lime. They are also used for road construction and in water purification systems.

If you have any questions concerning the matter, please contact Mr. Dennis L. Chew, telephone (504) 862-2523.

Sincerely,

Cletis R. Wagahoff
Chief, Planning Division

Enclosure

Planning Division
Environmental Analysis Branch

June 18,1986

Mr. Charles A. Oravetz
Protected Species Management Branch
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Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Mr. Oravetz:

We are requesting information concerning listed and proposed threatened and/or endangered species which may be impacted by extension of Section 10 and Section 404 permits to dredge shells in the Gulf Coast Area (GCA). The GCA consists of Vermilion Bay, West and East Cote Blanche Bays, Atchafalaya Bay, Four League Bay, and a narrow margin along the shore of the Gulf of Mexico (Figure 1). Although clam shells (Rangia) occur in the GCA, only oyster shells are currently dredged.

The oyster shell deposits are found in reefs, with millions of cubic yards of shell more or less cemented together. The fossil shells are buried under 4 to 8 feet of silty clay. These accumulations of fossil shells are dredged as a local source of calcium carbonate and aggregate. The type of dredge used is barge-like in design, with an excavating cutterhead, a suction ladder, a pumping system, and a materials washing and screening plant. Shell recovery is accomplished by hydraulic suction. As the cutterhead digs through the shell deposit, it moves forward by hauling in on anchor cables, causing the dredge to swing from side to side, pivoting on one of its spuds. A matrix of mud and shell enters through the cutterhead, and is pumped over a series of sizing screens and rotary washers. As the dredge pivots, the dredged material is directed back into the dredge area through a submerged discharge pipe. Most of the discharge resettles in the area of the slow-moving dredge, and the resulting bottom configuration, just after dredging, is a series of shallow troughs and mounds.

The oyster shells are used in the manufacture of cement, glass, chemicals, pharmaceuticals, wallboard, chicken and cattle feed, and agricultural lime. They are also used for road construction and in water purification systems.

If you have any questions concerning the matter, please contact Mr. Dennis L. Chew, telephone (504) 862-2523.

Sincerely,

Cletis R. Wagahoff
Chief, Planning Division

Enclosure

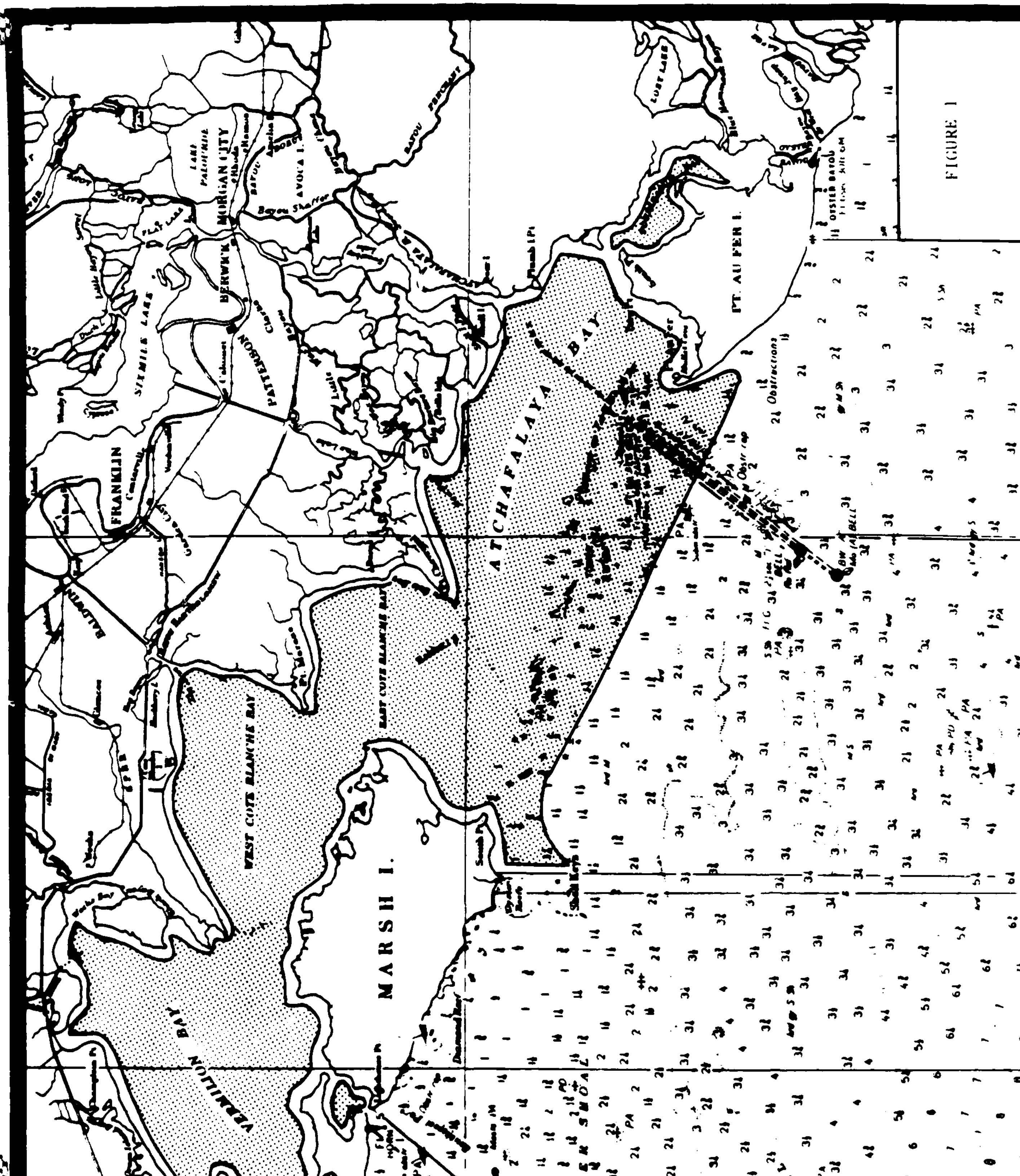

ATCHAFALAYA BAY
MARSH I.
VERMILION BAY
WEST COTE BLANCHE BAY
EAST COTE BLANCHE BAY
PT. AU FER I.
FRANKLIN
BERWICK
MORGAN CITY
PATTERSON
BALDWIN
SIX MILE LAKE
Obstructions

FIGURE 1

United States Department of the Interior
FISH AND WILDLIFE SERVICE
JACKSON MALL OFFICE CENTER
300 WOODROW WILSON AVENUE, SUITE 316
JACKSON, MISSISSIPPI 39213

June 18, 1986

IN REPLY REFER TO:
Log No. 4-3-86-547

Mr. Cletis R. Wagahoff
Department of the Army, Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160-0267

Dear Mr. Wagahoff:

This responds to your letter of June 18, 1986, concerning the extension of Section 10 and Section 404 permits to dredge shells in the Vermillion Bay, West and East Cote Blanche Bays, Atchafalaya Bay, Four League Bay, and a narrow margin along the shore of the Gulf of Mexico encompassing portion of Vermillion, Iberia, and St. Mary parishes of Louisiana.

We have reviewed the information you enclosed relative to the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

Our records indicate no endangered, threatened or proposed species, or their critical habitat occurring in the project area. Therefore, no further endangered species consultation will be required for this project, as currently described.

If you anticipate any changes in the scope or location of this project, please contact Cary Norquist, telephone 601/965-4900, for further coordination.

We appreciate your participation in the efforts to enhance the existence of endangered species.

Sincerely yours,

Dennis B. Jordan

Dennis B. Jordan
Field Supervisor
Jackson Endangered Species Office

cc:
ES, FWS, Lafayette, LA
Department of Wildlife & Fisheries, New Orleans, LA

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

July 8, 1986 F/SER23:PWR:dcp

Mr. Cletis R. Wagahoff
Chief, Planning Division
New Orleans District, COE
P. O. Box 60267
New Orleans, Louisiana 70160-0267

Dear Mr. Wagahoff:

This responds to your June 18, 1986, letter regarding information on threatened/endangered species which may occur in areas proposed for shell dredging (oyster and clam shells). The Gulf Coast Area (GCA) identified consists of Vermilion Bay, West and East Cote Blanche Bays, Atchafalaya Bay, Four League Bay, and a narrow margin along the shore of the Louisiana Gulf. The attached list provides the threatened and endangered species under National Marine Fisheries Service jurisdiction that may be present in the project area.

For a major federal action, the agency must conduct a biological assessment to identify any endangered or threatened species which may be affected by such action. The biological assessment must be complete within 180 days after receipt of the species list, unless it is mutually agreed to extend this period. The components of a biological assessment are also attached.

At the conclusion of the biological assessment, the Federal agency should prepare a report documenting the results. If the biological assessment reveals that the proposed project may affect listed species, the formal consultation process shall be initiated by writing to the Regional Director at the address on the letterhead. If no effect is evident, there is no need for formal consultation. We would however, appreciate the opportunity to review your biological assessment.

If you have any questions, please contact Paul Raymond, Fishery Biologist, FTS 826-3366.

813-893-3366

Sincerely yours,

Paul W. Raymond
for

Charles A. Oravetz, Chief
Protected Species Management Branch

Enclosures

cc: F/M412
F/SER11

Endangered and Threatened Species and Critical Habitats Under NMFS Jurisdiction

Louisiana Bays

LISTED SPECIES	SCIENTIFIC NAME	STATUS	DATE LISTED
Kemp's (Atlantic) ridley sea turtle	*Lepidochelys kempi*	E	12/02/70
loggerhead sea turtle	*Caretta caretta*	Th	7/28/78

SPECIES PROPOSED FOR LISTING
None

CRITICAL HABITAT
None

CRITICAL HABITAT PROPOSED FOR LISTING
None

Guidelines for Conducting a Biological Assessment

(1) Conduct a scientifically sound on-site inspection of the area affected by the action. Unless otherwise directed by the Service, include a detailed survey of the area to determine if listed or proposed species are present or occur seasonally and whether suitable habitat exists within the area for either expanding the existing population or reintroducing a new population.

(2) Interview recognized experts on the species listed, including those within the Fish and Wildlife Service, the National Marine Fisheries Service, state conservation agencies, universities and others who may have data not yet found in scientific literature.

(3) Review literature and other scientific data to determine the species distribution, habitat needs, and other biological requirements.

(4) Review and analyze the effects of the action on the species, in terms of individuals and population, including consideration of the cumulative effects of the action on the species and habitat.

(5) Analyze alternative actions that may provide conservation measures.

(6) Conduct any studies necessary to fulfill the requirements of (1) through (5) above.

(7) Review any other information.

Planning Division
Environmental Analysis Branch

November 25,1986

Mr. Charles A. Oravetz
Protected Species Management Branch
National Marine Fisheries Service
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Mr. Oravetz:

In accordance with the Endangered Species Act of 1973, a biological assessment which addresses the potential impacts of oyster shell dredging on Kemp's ridley and loggerhead turtles in coastal Louisiana is submitted.

Based on this biological assessment, the U.S. Army Corps of Engineers, New Orleans District, has determined that the project, as proposed, would have no adverse impact on the subject species in Four League, Atchafalaya and East Cote Blanche Bays.

It is our opinion, based on these considerations, that initiation of consultation is not necessary at this time. If you have any questions on the assessment, please feel free to contact Ms. Diane E. Ashton of this office, telephone (504) 862-1735.

Sincerely,

Cletis R. Wagahoff
Chief, Planning Division

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

December 9, 1986 F/SER23:PWR:dcp

Mr. Cletis R. Wagahoff
Chief, Planning Division
New Orleans District, COE
P. O. Box 60267
New Orleans, LA 70160-0267

Dear Mr. Wagahoff:

This responds to your November 25, 1986, letter regarding proposed oyster shell dredging in coastal Louisiana, specifically Atchafalaya Bay, Four League Bay, and East Cote Blanche Bay. A biological assessment (BA) was transmitted pursuant to Section 7 of the Endangered Species Act of 1973 (ESA).

We have reviewed the BA and concur with your determination that populations of endangered/threatened species under our purview would not be affected by the proposed action.

We wish to commend you and your staff (Ms. Diane Ashton) for the thoroughness and quality of the BA, it is literally one of the best assessments this office has received. We look forward to future consultations regarding ESA requirements and our interagency responsibilities.

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified or critical habitat determined that may be affected by the proposed activity. If you have any new information or questions concerning this consultation, please contact Mr. Paul Raymond, Fishery Biologist, at FTS 826-3366.

Sincerely yours,

Charles A. Oravetz

Charles A. Oravetz, Chief
Protected Species Management Branch

cc: F/M412
F/SER11
F/SER112

APPENDIX B

LIST OF REGULATIONS AND RESTRICTIONS
APPLICABLE TO SHELL DREDGING (ALL AGENCIES)

TABLE OF CONTENTS

APPENDIX B

LIST OF REGULATIONS AND RESTRICTIONS APPLICABLE TO SHELL DREDGING (ALL AGENCIES)

Introduction

Operations of the shell dredging industry are regulated by the U.S. Army Corps of Engineers (USACE), the Louisiana Department of Natural Resources (DNR), and the Louisiana Department of Wildlife and Fisheries (LDWF). These restrictions are the result of years of negotiation and compromise between the above-listed agencies and members of the industry. The restrictions are often identical *from one* agency to another, and the industry must comply with all.

ATCHAFALAYA BAY SHELL DREDGING REGULATIONS

All operations will be conducted in compliance with U.S. Army Corps of Engineers, Environmental Protection Agency, U.S. Coast Guard, Louisiana Department of Environmental Quality, Louisiana Department of Wildlife and Fisheries, and the Louisiana Department of Natural Resources rules, restrictions, and regulations. (USACE)

Monitoring System

1. Permittee shall at its expense install a Loran C continuous location recording system (accurate to 100 feet) or a similar device acceptable to the Department of Wildlife and Fisheries and the Department of Natural Resources on each operating shell dredge within six (6) months of the effective date of the permit. The system shall be certified tamper proof by the manufacturer and accessible to the Coastal Management Section (CMS), Department of Louisiana Wildlife and Fisheries (LDWF) or their designees. Permittee shall notify CMS/DNR within one working day after a malfunction of the system. Each dredge shall remain within 1,000 feet of its position at the time the malfunction occurs until CMS and LDWF have been contacted. (DNR)

> "Should a malfunction occur during non-working hours, permittee shall make reasonable efforts to notify CMS personnel at telephone numbers to be supplied to permittee. If after reasonable efforts, permittee is unable to notify CMS, dredges may continue to operate but CMS shall be notified as soon as possible and in no event more than one working day after the malfunction occurs. Dredging operations may continue during these periods, but permittee shall insure that no restricted zones are entered." (DNR)

2. Dredge must have a device which records all movements and locations of the dredge vessel. (1/1/83, LDWF)

3. Each dredge must have on board a person with authority to stop and/or move the dredge or other equipment upon notification by the designated representative of the department. (1/1/83, LDWF)

4. Records of each dredge's location recorded by the system shall be delivered to LDWF and shall be available for inspection by representatives of CMS or the public. (DNR)

5. Prior to installation of the system, a copy of the weekly reports submitted to LDWF shall also be submitted to CMS. Weekly reports to CMS shall include records of the dredge location during every twelve (12) hour period, the location of submerged reefs dredged, and the location of exposed reefs encountered during surveys. This report shall be submitted monthly after installation of the system described above. (DNR)

Archeological Restrictions

1. Should any archeological or historical materials (i.e. pottery, bone, timbers, ship fittings, etc.) be encountered in permittee's dredging

activities, their locations shall be noted or a map and their location given to CMS/DNR and the Division of Archeology, Office of Tourism, Louisiana Department of Culture, Recreation and Tourism. (DNR)

2. If any archeological or historical material (i.e., pottery, bone, timbers, ship fittings, etc.) are encountered, the locations of these finds will be mapped and the State Historic Preservation Officer (SHPO) will be immediately notified. Dredging will be discontinued in that area until SHPO approval is given to resume dredging activities in the subject area. (USACE)

Comprehensive Study of Ecological Effects

Permittees shall cooperate with CMS/DNR and/or the Coastal Protection Trust Fund Task Force or their designatees in a comprehensive study of the ecological effects of fossil oyster shell dredging within the central Louisiana coastal area which includes Atchafalaya Bay and Four League Bay. Permittee shall be required to furnish any and all data available to it in connection with such study. Such study may include but shall not be restricted to an investigation of water quality, benthic community and shoreline variations which may be caused by shell dredging operations. (DNR)

Dredging operations shall not damage the oyster beds, mercenaria clam beds or bottoms owned by the State where these operations damage or prove harmful to fish, oyster, aquatic or other wild life resources in said beds or water bottoms. (9/9/81, LDWF)

Permit Violations

Permittee shall be subject to the following actions under LA R.S. 49:213.17 for the violation of any condition of this permit (DNR):

1. The issuance of cease and desist order.

2. The suspension, revocation, or modification of this permit.

3. The institution of judicial action for an injunction, declaratory relieve, or other remedy as maybe necessary to insure against activities not in conference with law regulations or this permit.

4. The imposition of civil liability and assessment of damages.

5. The issuance of orders where feasible and practical for the payment of restoration cost or for actual restoration of areas disturbed.

6. The imposition of other reasonable and proper sanctions for uses conducted within the coastal zone not in accordance with law, regulations or this permit.

7. The imposition of cost and reasonable attorney fees where appropriate.

8. The imposition of a fine of not less that $100 and not more then $500, or imprisonment for not more than 90 days, or both, in instances where permittee is found to have knowingly and intentionally violated the law, rules and regulations, or any conditions of this permit.

Offsite Restoration

As compensation for disturbance of the water bottom during dredging, the permittee shall at it expense undertake offsite restoration when recommended by the Secretary of the Louisiana Department of Wildlife and Fisheries for improvement of the marine environment. Such offsite restoration shall not exceed one (1) acre of shell reef 1 foot thick for every 200,000 cubic yards dredged from the permitted area. These restoration reefs shall be no less than one (1) acre in size and shall be located in areas recommended by LDWF and CMS and which are restricted from shell dredging. (DNR)

Number of Dredges

Permittee shall not operate more than two shell dredges at any given time within the area covered by this permit. The number of dredges may be increased only after administrative review by the Secretary of Natural Resources. The Secretary may require the submission of additional environmental data before allowing any additional dredges. (DNR)

Dredge Discharge

The dredge discharge shall be directed over the dredged cut. After an area has been dredged, it shall be surveyed and level so as not to cause navigation hazards. (DNR)

Lessee shall fill (backfill with fines and overburden) and level cuts (intent is to leave a relatively smooth bottom). (LDWF)

Distance between any two operating dredges shall not be less than 300 yards. (5/18/82, Lake Charles, LDWF)

Duration of Permit

This permit shall be valid for five years from December 10, 1982 in the present form unless sooner revoked or modified for good cause shown (other than permit violations) after thirty (30) days written notice to permittee and opportunity for permittee to be heard on the alleged basis for revocation or modifications. Additionally, on the second and fourth anniversary of the original permit date, a mandatory administrative conference and public hearing will be held by the Secretary of the Department of Natural Resources in one or more of the parishes where the activity will be conducted to assess the environmental impact of permit activities to the lakes. Permittee may be required to produce at such conference all books, records, documents or data in its custody which may be of probative value in assessing the environmental impact of the activities of this permit. Good cause may include, but shall not be limited to, additional scientific data resulting from studies conducted

by the Department of Natural Resources, the Department of Wildlife and Fisheries, or other qualified individuals or entities. (6/23/83, DNR)

Additional Conditions

1. The applicant will notify the Coastal Management Section of the date on which approved work began on site. (DNR)

2. The permittee will advise U.S. Army Corps of Engineers, New Orleans District in writing upon commencement of dredging operations in a new zone. Zones are defined as the subunits of dredge lease areas in which operations are permitted on a schedule set by LDWF. (USACE)

3. The applicant shall insure that all sanitary sewage and/or related domestic wastes generated during the subject project activity and at the site, thereafter, as may become necessary shall receive the equivalent of secondary treatment with disinfection prior to discharge into any of the streams or adjacent waters of the area, or in the case of total containment, shall be disposed of in approved sewerage and sewage treatment facilities, as is required by the State Sanitary Code. Such opinion as may be served by those comments offered herein shall not be construed to suffice as any more formal approval(s) which may be required of possible sanitary details (i.e. provisions) scheduled to be associated with the subject activity. Such shall generally require that appropriate plans and specifications be submitted to DNR for purposes of review and approval prior to any utilization of such provisions. (DNR)

ATCHAFALAYA BAY SHELL DREDGING RESTRICTIONS

All operations will be conducted in compliance with U.S. Army Corps of Engineers (USACE), Environmental Protection Agency, U.S. Coast Guard, Louisiana Department of Environmental Quality, Louisiana Department of Wildlife and Fisheries (LDWF), Louisiana Department of Natural Resources (DNR) rules, restrictions, and regulations. (USACE)

No dredging shall occur in the following restricted areas:

1. No shell dredging will be performed in the Gulf of Mexico east of Point Au Fer until studies of impacts are completed and the information evaluated by the New Orleans District. No dredging in the restricted area of the Gulf of Mexico will be performed without specific approval of the New Orleans District, Louisiana Coastal Management Section (CMS) and the Louisiana Department of Wildlife and Fisheries (LDWF). The Gulf of Mexico is defined as the waters located seaward of the baseline from which the territorial sea is measured. (USACE)

2. Within 1,000 feet of exposed subaerial shell reefs; permittee shall avoid subaqueous shell reefs to the maximum extent pracicable and shall not dredge any reefs exceeding 0.1 acre in size. Subaqueous shell reefs shall be defined as those reefs which are above the water bottom but beneath the water surface at mean low tide. (6/23/83, DNR)

3. Within 1,500 ft. of natural land masses or exposed reefs. Exposed reefs and natural land masses are defined as those features that are above the water surface at the datum listed as 0.0 ft. mean lower low water (MLLW) on Dept. Commerce National Oceanographic Survey Chart No. 11344, 11349, 11351, 11356. (LDWF)

4. No dredging operations may be performed within 1,000 feet of exposed oyster reefs (any reef not covered by mud or sand). (USACE)

5. Within 1,500 feet of vegetated emergent land masses. (USACE)

6. Within 1,500 feet of any shoreline except as noted. (USACE)

7. Within 1,000 feet of any active oil or gas well drilling rig. (USACE, DNR)

8. Within 300 feet of an active oil or gas well platform or active production facilities platforms. (USACE, DNR)

9. Over pipelines where locations are known. (USACE)

10. No dredging operations may be performed west of longitude 91°37' or in Four League Bay under authority of this permit. (USACE)

11. Within all the areas east of Marsh Island described in the 10 December 1976 Agreement among the Louisiana Department of Justice, LDWF and Shell Dredging Industry representatives as further described in a letter to Dr. Llyle St. Amant, Assistant Secretary LDWF, and Mr. Frederick W. Ellis, Special AssistantAttorney General (see attached).

The restricted area for this part shall include both lists No. 1 and No. 2 further described in the aforementioned 10 December 1976 document. Note that the whole of Fisherman's Reef (X=1,882,306; Y=270,590 ft.) is included in the above restricted area in addition to the western remnants of the Point Au Fer Reefs. (DNR)

12. No dredging shall be conducted in the areas per agreement between the Lousiana Department of Justice (LDJ) and the Louisiana Wildlife and Fisheries Commission (LWLFC). These areas are identified in a letter dated December 10, 1976, from LDJ and LWLFC. These areas are located along and to either side of a line from South Point on Marsh Island to Point Au Fer and includes waters to either side of the baseline from which the terrestrial sea is measured, Fisherman's Reef, Point Au Fer Reefs, White Shell Reef, and other areas as indicated in the subject letter. (USACE)

13. There shall be no shell dredging in an area described as 1,500 feet either side of a line running from Point Au Fer to South Point, located on Marsh Island, known as the "Louisiana Attorney General's Line". (LDWF)

14. Within 0.5 mile of the existing shoreline in Atchafalaya Bay and Four League Bay. (DNR)

15. No dredging within the Atchafalaya Delta Wildlife Management Area without specific approval of LDWF. (USACE)

16. Within waters that are -2 feet NGVD and more shallow around the Lower Atchafalaya River Outlet delta and the Wax Lake Outlet delta. (USACE)

17. In the areas designated for no dredging mutually agreed to by the permittee's representative and personnel of the Fish and Wildlife Service in December 1982. These areas concern work near the Atchafalaya River delta and the Wax Lake Outlet delta. In the Atchafalaya River delta, the area is bounded within lines connected by Lambert coordinates X 2,024,000 Y 282,900 (Plumb Island Point), south to X 2,024,000 Y 268,000, west to X 2,018,000 Y 268,000, south to X 2,018,000 Y 263,500, west to X 1,987,500 Y 263,500, north to X 1,987,500 Y 281,900, northeast to X 2,006,125 Y 298,750 (in Shell Island Pass). (USACE, DNR)

18. In the Wax Lake Outlet delta, the area is bounded within lines connected by Lambert coordinates X 1,984,100 Y 308,000, (on shoreline southeast of Belle Isle Lake), southwest to X 1,977,700 Y 300,500, west-southwest to X 1,960,400 Y 294,200, northwest to X 1,950,000 Y 317,000 (on shoreline approximately 3.5 miles west of Wax Lake Outlet). (USACE, DNR)

19. Any of the areas described above which are not excluded by the Louisiana Department of Wildlife and Fisheries may be dredged by the permittee only upon the approval of the Secretary of the Louisiana Department Of Wildlife and Fisheries and the Secretary of the Department of Natural Resources, after a public hearing in the parish where the proposed dredging is to take place. (6/23/83, DNR)

COTE BLANCHE-ATCHAFALAYA BAY
PROPOSED RESTRICTIONS ON SHELL DREDGING BY RADCLIFF MATERIALS, INC., AND LAKE CHARLES DREDGING AND TOWING COMPANY (12/10/76)

List No. 1, consists of those areas where it is proposed that no dredging be allowed and should be totally excluded from permit.

List No. 2, is composed of those areas wherein provisional dredging should be allowed conditioned by the notice and approval procedure set forth at the head of that list.

LIST NO. 1

Areas to be totally excluded from permit:

Area 1: Those points and areas outlined and shaded in blue on a certain map of the Point Auf Fer Shell Reef, dated July 10, 1973, and prepared by Radcliff Materials, Inc., will be excluded from the permit area.

Area 2: The White Shell reef and any other areas which were the subject of a 1973 agreement amongst the Louisiana Wildlife and Fisheries Commission, the Louisiana Department of Justice and Radcliff Materials, Inc., wherein such areas were prohibited to dredging will further be excepted from the permits.

Area 3: The following described points and the surrounding areas lying within three hundred (300) feet of the low water line of the low water elevations found at said points, described within the Louisiana Plane Coordinate System South Zone, as:

(a) X=1,933,172 ft.
Y=264,238 ft.

(b) X=1,924,399 ft.
Y=268,936 ft.

(c) X=1,914,373 ft.
Y=270,380 ft.

(d) X=1,896,827 ft.
Y=275,747 ft.

(e) X=1,882,306 ft.
Y=270,590 ft.

(f) X=1,872,418 ft.
Y=277,460 ft.

Which points are depicted more fully on that set of maps employed in United States vs. Louisiana, No. 9 Original, in the United States Supreme

court and styled "set of 54 maps" and particularly on maps numbered 1, 3 and 4 of the set of 5 (Atchafalaya Bay Area) of said "set of 54 maps".

LIST NO. 2

AREAS SUBJECT TO NOTICE AND APPROVAL
AGREEMENT FOR CONDITIONAL DREDGING

For those land, reefs, or other waterbottom and points described in areas 4, 5 and 6 dredging will be permitted only after the operator has served written notice of dredging plans at least 60 days prior to the commencement of operation on the Louisiana Department of Justice, Lands and Natural Resources Section and said section gives prior written consent and approval for the dredging to continue.

List of areas to be subject to notice agreement under proposed permit conditions:

Area 4: Any lands, reefs or waterbottoms located within one thousand five hundred (1,500) feet of a line segment of that line between points X=1,863,474 ft., Y=298,772 ft. on the South point of Marsh Island, and X=1,993,420 ft., Y=241,939 ft. on Point au Fer, which line segment lies between the points on said South Point to Point au Fer line where X=1,883,500 ft. and X=1,934,700 ft.

Area 5: That area lying within one thousand five hundred (1,500) feet of a line segment described as running east and west, with a constant Y value of Y=276,704 ft., terminating at its east end where X=1,908,405 ft. and to the west where X=1,895,415 ft.

Area 6: In addition to the points and areas comprising Areas 3,4 and 5 above, no dredging operations shall be conducted within three hundred (300) feet of any of the low waterline of the low water elevations or other points depicted as small circles on the attached map, with assigned X and Y Louisiana Plane Coordinate System, South Zone coordinates, and lying outside of the afore-said areas unless the prior written notice and approval method set out herein above is followed.

SHELL DREDGING RESTRICTIONS

Vermilion and East and West Cote Blanche Bays
Gulf of Mexico and West Cote Blanche Bay
St. Mary, Iberia, and Vermilion Parishes

All operations will be conducted in compliance with U.S. Army Corps of Engineers (USACE), Environmental Protection Agency, U.S. Coast Guard, Louisiana Department of Environmental Quality, Louisiana Department of Wildlife and Fisheries (LDWF), Louisiana Department of Natural Resources (DNR) rules, restrictions, and regulations. (USACE)

No dredging shall occur in the following restricted areas:

1. No shell dredging will be performed in the Gulf of Mexico west of Shell Keys National Wildlife Refuge until studies of impacts are completed and the information evaluated by the New Orleans District. No dredging in the restricted area of the Gulf of Mexico will be performed without specific approval of the New Orleans District, Louisiana Coastal Management Section (CMS) and the Louisiana Department of Wildlife and Fisheries (LDWF). The Gulf of Mexico is defined as the waters located seaward of the baseline from which the territorial sea is measured. (USACE)

2. Within 1,000 feet of exposed subaerial shell reefs; permittee shall avoid subaqueous shell reefs to the maximum extent practicable and shall not dredge any reefs exceeding 0.1 acre in size. Subaqueous shell reefs shall be defined as those reefs which are above the water bottom but beneath the water surface at mean low tide. (6/23/83, DNR)

3. Within 1,500 ft. of natural land masses or exposed reefs. Exposed reefs and natural land masses are defined as those features that are above the water surface at the datum listed as 0.0 ft. mean lower low water (MLLW) on Dept. Commerce National Oceanographic Survey Chart No. 11344, 11349, 11351, 11356. (LDWF)

4. No dredging operations may be performed within 1,000 feet of exposed oyster reefs (any reef not covered by mud or sand). (USACE)

5. Within 1,500 feet of vegetated emergent land masses. (USACE)

6. Within 1,500 feet of any shoreline except as noted. (USACE)

7. Within 1,000 feet of any active oil or gas well drilling rig. (USACE, DNR)

8. Within 300 feet of an active oil or gas well platform or active production facilities platforms. (USACE, DNR)

9. Over pipelines where locations are known. (USACE)

10. In Southwest Pass between the mainland and Marsh Island from Southwest Point to Lighthouse Point. (USACE, DNR)

11. Within 1 mile of Marsh Island. (USACE, DNR, LDWF)

12. Within 1 mile of Sally Shoal. (USACE, DNR)

13. No dredging of "Sally Shoals". (LDWF)

14. Within 1 mile of Shell Keys National Wildlife Refuge. (USACE)

15. The "Cove" area near Cypremort Point, including that area east of 91°53'30" longitude line in the vicinity of the "Cove" between Cypremort Point and Blue Point. (USACE, DNR)

16. No dredging will be conducted within the areas known as Mound Point and Diamond Keys. (USACE)

17. The area including the "Trash Pile," Weeks Bay and NE Vermilion Bay east of the boundary described by the following coordinates: 91°54'00"W, 29°49'42"N; southerly to 91°54'00"W, 29°46'30"N; easterly to 91°53'30"W, 29°46'30"N; and southerly to its intersection with the northern boundary of the Dry Reef restricted area (91°53'30"W, 29°42'42"N). (USACE, DNR)

18. The "Dry Reef" area in Vermilion Bay between Cypremort Point and Southwest Pass bounded by the following coordinates: 29°42'10"N, 91°51'30"W (NE corner); 29°43'00"N, 91°53'15"W (NW corner); 29°40'00"N, 91°56'30"W (SW corner); and 29°38'30"N, 91°56'30"W (SE corner). (USACE, DNR)

19. Little White Lake area located westerly from a North-South line drawn from Redfish Point to Vermilion River Cutoff. (USACE, DNR)

20. Within 500 ft. on either side of the marked navigation channel from Vermilion River Cutoff to Southwest Pass. (USACE, DNR)

21. In the Gulf of Mexico west of North-South line originating approximately 0.5 miles west from an unnamed bayou between South Point and Mound Point, Marsh Island (91°47'54"W, 29°29'06"N) and terminating at the three mile Louisiana offshore limit. This North-South line is intended to be the same line set by LDWF in its shell dredging lease.

22. Within all the areas east of Marsh Island described in the 10 December 1976 Agreement among the Louisiana Department of Justice, LDWF and Shell Dredging Industry representatives as further described in a letter to Dr. Lyle St. Amant, Assistant Secretary LDWF, and Mr. Frederick W. Ellis, Special Assistant Attorney General (See attached). The restricted area for this part shall include both lists No. 1 and No. 2

further described in the aforementioned 10 December 1976 document. Note that the whole of Fisherman's Reef (X = 1,882,306; Y = 270,590 ft.) is included in the above restricted area in addition to the western remnants of the Point Au Fer Reefs.

In addition, that area 1500 feet north and south of the "Attorney General's Line", SW from Point Chevreuil as further described in the LDWF Shell Dredging Regulations adopted December 21, 1982, shall be included as a restricted area in the permit. (USACE, DNR)

23. Within 0.5 miles of the existing shoreline in Vermilion, West Cote Blanche and East Cote Blanche Bays with the exception of the 1.0 mile restricted zone north and east of Marsh Island. (DNR)

24. No dredging may be performed east of longitude 91°37'. (USACE)

25. Within 500 ft. on either side of the marked NWSE navigation channel from Vermilion River Cutoff to Southwest Pass. (USACE)

26. Any of the areas described above which are not excluded by the Louisiana Department of Wildlife and Fisheries may be dredged by the permittee only upon the approval of the Secretary of the Louisiana Department of Wildlife and Fisheries and the Secretary of the Department of Natural Resources, after a public hearing in the parish where the proposed dredging is to take place. (6/23/83, DNR)

LEASE

STATE OF LOUISIANA

PARISH OF ORLEANS

This Agreement made by and between the LOUISIANA DEPARTMENT OF WILDLIFE AND FISHERIES, a creature of the State of Louisiana, herein acting through JESSE J. GUIDRY, its Secretary (party of the First Part); and LAKE CHARLES DREDGING AND TOWING COMPANY, INC., a corporation duly organized and existing under the laws of the State of Louisiana, represented herein by R. J. ROMERO, its Assistant Secretary, and RADCLIFF MATERIALS, INC., an Alabama corporation qualified to do business in Louisiana, herein represented by C. A. TORBERT, JR., its President (parties of the Second Part).

The Louisiana Department of Wildlife and Fisheries may hereinafter be referred to as DEPARTMENT; and LAKE CHARLES DREDGING AND TOWING COMPANY, INC., and RADCLIFF MATERIALS, INC., may hereinafter jointly be referred to as LESSEES and may hereinafter individually be referred to as LESSEE.

Subject to the reservations, terms, royalties and conditions hereinafter cited, the Department sells and grants to the LESSEES, as co-owners, each owning an undivided one-half interest, the exclusive right and privilege of taking and removing oyster shells, clam shell, reef shell and other shell deposits from any and all of the shell reefs and water bottoms situated within the Parish of Vermilion, and those portions of the Parishes of Iberia and St. Mary, in the State of Louisiana, which lie between longitude ninety-one degrees thirty-seven minutes (91° 37') west, as the eastern boundary, and the boundary line between the Parishes of Cameron and Vermilion, as the Western boundary, and the outer boundaries of the State of Louisiana, and including any and all inland waterways and bodies of water lying within said boundaries, less and except the following areas which are presently included in that certain lease and grant, date June 20, 1973, from said Department, to the Olin Corporation: All reefs and all water bottoms in Vermilion Bay, West Cote Blanche Bay, Southwest Pass, and the Gulf of Mexico, within the boundaries described as follows, to-wit:
Beginning at a point "A" on the Northwest extremity of Lighthouse Point, and extending twenty-two thousand (22,000') feet, more or less in an Easterly and Northerly direction, following the shoreline of Marsh Island to a point "B" near the Northeast corner of Southwest Pass; thence North to a point "C" on the shoreline of the mainland; thence in a Westerly and Southerly direction, following the shoreline to a point "D" opposite Lighthouse Point; thence Southeast to the point of beginning, all situated in the Parishes of Iberia and Vermilion, comprising six thousand (6,000) acres, more or less, and all subject to tidal overflow; and the following areas excluded from the lease by action of the Department, affecting Lake Charles Dredging and Towing Company, Inc. and Radcliff Materials, Inc. and dated November 26,

(a) Any area lying within one nautical mile from the perimeter of Marsh Island as determined from Coast and Geodetic Survey Chart #1276 and 11349; and

(b) The "Sally Shoals" reef in West Cote Blanche Bay between Marsh Island and Cypremort Point as shown on Coast and Geodetic Survey Chart #11348 dated June 29, 1974.

There is specifically and expressly excepted from the within lease the water bottoms of Sabine Lake and any other water bottoms situated in Vermilion, Iberia and St. Mary Parishes presently under exclusive lease.

1.

The rights, privileges and obligations granted herein are joint and several for all Purchasers except to the extent herein set forth. The joint and several rights and privileges herein granted shall be for a period of fifteen (15) years beginning May 18, 1982, and ending may 17, 1997, and shall be subject to all existing oil and gas pipeline rights-of-way, mineral leases and servitudes granted by third parties and the State of Louisiana through the Department of Natural Resources located in the area hereinabove described and of record as of the date of this Agreement.

2.

The term of this Agreement may be extended at the option of the LESSEES who have not lost or forfeited their rights hereunder for two (2) successive periods of five (5) years each conditioned upon the LESSEES giving to the Department and the Louisiana Wildlife and Fisheries Commission written notice of its intention to exercise such extension option at least one (1) year prior to the expiration date of the term then in effect and such written notice having been given by the LESSEES to the Department, this Agreement shall be extended without further formality.

3.

As consideration under this Agreement, the LESSEES, subject to the adjustment set forth in the last paragraph of this item 3, shall pay the Department the following royalties;

(a) During the period May 18, 1982, through and including December 31, 1982, the LESSEES shall pay the Department a royalty of twenty-five cents (25¢) per cubic yard for all shells and/or other shell deposits removed by the LESSEES from the above described water bottoms.

(b) Beginning on January 1, 1983, and on the first day of January in each year thereafter during the balance of this Agreement, the LESSEES shall pay the Department a royalty for each such calendar year which shall be increased or decreased from the previous year's cubic yard royalty provided for in (a) above, based on the following formula:

Said royalty of twenty-five cents (25¢) per cubic yard shall be adjusted on the first day of January of each year for the ensuing twelve month period by multiplying said twenty-five cents (25¢) per cubic yard royalty by the quotient in which the numerator shall be the All Urban Consumer Price Index, or its successor Index, calculated by the appropriate agency of the Federal Government and publicized by the Federal Reserve Bank of St. Louis, Missouri (hereinafter called the ALL URBAN CONSUMER PRICE INDEX), for the month of December immediately preceding the twelve month period for which said royalty is being adjusted, and the denominator shall be the All Urban Consumer Price Index for the month of April, 1982. The resulting quotient expressed in a percentage shall be applied to the twenty-five cents (25¢) base royalty and shall be the basis for the new royalty. An example of the calculation is attached hereto as Exhibit A. In the event the All Urban Consumer Price Index has not been published in time to compute any monthly payment due the Department by LESSEES, then LESSEES shall pay the Department the same royalty paid during the preceding month or months and as soon as the determining monthly All Urban Consumer Price Index is published, LESSEES shall make such adjustments to the previous royalty payments as may be necessary to correctly pay the Department the adjusted royalties due hereunder.

The foregoing notwithstanding, in no event shall the royalty payable by LESSEES to the Department throughout the period of this Contract be less than twenty-five cents (25¢) per cubic yard.

Notwithstanding anything herein to the contrary, the Department shall have the right, at the end of each five year period of this lease, to review the base royalty of twenty-five cents (25¢) and, if the real value of the resources has increased or decreased to an extent not covered by the inflation provisions of this contract and all economic and competitive conditions prevalent at the time, then to increase or decrease the base royalty by an amount as may be determined by the Department but in no event shall such increase exceed 25%.

4.

It is expressly understood and agreed that in the event of any increase by the Legislature of the State of Louisiana in the prevailing royalty rates for the removal of shell or shell deposits from any of the water bottoms of this state, the LESSEES shall pay as consideration under this Agreement any increased royalty per cubic yard so provided for by action of the Louisiana Legislature for shells and/or shell deposits thereafter taken by the LESSEES.

5.

It is understood that payment of royalty for all shells and/or shell deposits removed by the LESSEES during any one calendar month shall be made on or before the 15th day of the succeeding month, all in a manner consistent with the applicable law of the State of Louisiana.

6.

Each LESSEE warrants that each LESSEE has currently under such LESSEE'S exclusive ownership and/or control an adequate supply of dredges, adequately powered tow boats for the operating conditions, barges, cranes, machinery, tools and implements of every kind or character which may be necessary to the taking and removal of shell and/or shell deposits under the terms of this Agreement. It is expressly understood that the Department shall incur no liability or expense of any kind in connection with the ownership, control and operation of such equipment by each such LESSEE, including but not limited to all court costs, cost of defense and any judgments arising from any claims, actions or causes of action by all third parties, each such LESSEE, its employees, agents, officers and directors, successors and assigns, their employees, agents, officers and directors caused by each such LESSEE, its employees, agents, successors and assigns in the exercise of the dredging rights and privileges granted by this Agreement.

7.

Each LESSEE agrees that such LESSEE shall be liable and responsible only for damage or damages, whether to the property of the State or of any individual, firm or corporation, or to any person or persons, caused by the negligence or breach of contract of such LESSEE or by such LESSEE'S agents, directors, or employees of any kind, and one of the LESSEES shall be responsible for damage caused by any of the other LESSEES, their agents, directors, or employees. Each LESSEE, its successors and assigns agree to indemnify the Department for all such damage or damages and to hold the Department harmless from all such damage or damages caused by such Purchaser, including assuming the cost and expense of defending all claims, actions, or causes of action which are or may be filed seeking such damage or damages. Each LESSEE shall specifically obtain insurance coverage of this indemnity provision and shall furnish the Department with satisfactory evidence of such coverage of not less than three million dollars.

8.

At the Department's request, each LESSEE shall notify the Department in writing, at least ten (10) days prior to putting into actual service any dredge, barge or tow boat used in the removal of shells and/or shell deposits, together with the capacity of each, and the Department may thereupon verify the measurements of said barges. In case the giving of such notice by the LESSEES become impractical, then the LESSEES shall give written notice within ten (10) days after such vessel is placed in service.

9.

Each LESSEE binds and obligates itself not to dredge within three hundred (300) yards of the dredging operations of any of the other LESSEES hereunder or any Sublessees hereunder.

10.

Each LESSEE, on or before the 15th day of each month, shall furnish the Department with a detailed statement, duly sworn to and subscribed, showing the number of times each and every barge has removed shells from the above described beds or water bottoms during the preceding month, the location from whence removed, the dates when same shells were removed, and the quantities of shell so removed; and it shall accompany same with full payment therefor. This statement shall not be conclusive upon the Department, and it reserves the right, and each said LESSEE so agrees, to permit the Department's authorized representative to examine any and all of each LESSEE'S books, records and memoranda of whatever kind of nature, pertaining to or having any connection whatever with the removal or sale of said shells.

11.

The Department further reserves the right, and each LESSEE agrees, to have the Department's agents or representative inspect the barges, boats, and dredges, etc., in which the said shells are removed, and to keep a check on the number thereof, and also to determine by whatever means it may deem necessary, the number of cubic yards of shells which have been removed from the hereinabove described beds or water bottoms, and to require the payment therefor.

12.

LESSEES agree that the quantity of shells removed by LESSEES will yield to the Department not less than THIRTY THOUSAND DOLLARS ($30,000.00) per year, starting with the year beginning on the date hereof, and continuing therefrom throughout the life of this Contract. LESSEES further agree that in the event for any reason LESSEES do not remove sufficient shells to aggregate in total, at the price per yard stipulated above, the guaranteed yield to the Department of THIRTY THOUSAND DOLLARS ($30,000.00) per year, LESSEES will pay to the Department an amount sufficient to produce the minimum sum of THIRTY THOUSAND DOLLARS ($30,000.00) per year as stipulated.

13.

In case any LESSEE fails to make payment according to the reservations, terms and conditions hereinabove stipulated within the time provided in this agreement, or should any LESSEE fail or refuse to comply with any provisions in this agreement, on and after ten (10) days from the date said payments are due, or said failure or refusal to comply herewith, this agreement shall be automatically revoked, terminated and canceled as to the offending LESSEE provided that the LESSEE shall be given written notice of any such failure to comply with a provision of this Agreement, and LESSEES shall have five (5) days after receipt of such notice in which to correct such default. In the event such default is not cured within the said five (5) days period, then this Agreement shall be terminated without further formality, except for a written notice of such revocation and termination to be forwarded by the Secretary for the Department to such LESSEE at its domicile and to the

Clerks of Court in the Parishes wherein the hereinabove described Lakes are located, by United States mail, postage prepaid. Nothing to the contrary withstanding the provisions of this paragraph shall not release or relieve each LESSEE, its successors and assigns from the liability assumed and established in paragraphs 6 and 7 of this Agreement, arising on or before the date of cancellation or forfeiture of the rights and privileges herein provided.

14.

The privilege of assigning this Agreement by any LESSEE is acknowledged, but such assignment shall not be binding upon the Department until it has been furnished with written notice of the assignment, together with a copy thereof, approved by the Department, except that such approval shall not be required if such assignment and all rights hereunder are made to a bona fide successor or subsidiary of said LESSEES, or if pledged as collateral security for any and all purposes whatsoever. It is expressly understood, however, that any one of said LESSEES, with the written approval of the Department, may issue to any person, firm or corporation of its choice, from time to time, and at any time, permits to take and remove shells and shell deposits from the area covered hereby, and in such event, the LESSEE granting such permit shall contract with such permittee to take or remove shells and shell deposits from the area covered hereby and said LESSEE shall remain liable for the performance of all duties and obligations herein imposed.

15.

LESSEES further agree and obligate themselves to execute, simultaneously with the execution of this Agreement, in favor of the Department, in the manner prescribed by law, a bond in the sum of THIRTY THOUSAND DOLLARS ($30,000.00) with a solvent surety company authorized to do business in Louisiana as surety thereon, conditioned that LESSEES will faithfully, promptly and diligently carry out and perform all of the conditions and obligations herein imposed, described and assumed by this Agreement, which bond shall be renewable annually during the base term of this Agreement or any extended period thereof.

16.

Each LESSEE further agrees, binds and obligates itself before commencing operations in accordance with this Agreement, to furnish the Department a map, plat or chart to scale as specified by the Department of the major areas of the beds and water bottoms hereinabove described and from which such LESSEE shall take and remove shells and/or shell deposits, which map, plat or chart shall have marked thereon the location at which such LESSEE shall commence its operations; and from time to time, such LESSEE shall notify the Department, in writing, of any and every major change of location of its operations, and by correcting said map, plat or chart aforesaid by marking its new major areas of operation as well as each and every former major area of operation under this Agreement.

17.

Upon the termination of this Agreement, either by the expiration of its terms or by forfeiture or revocation, or for any other cause, the said LESSEES agree and bind themselves immediately to turn over to the Department all maps, records of borings, and other data relative to said shells and/or shell deposits which it may have obtained, and such maps, records, and other data shall be and remain the property of the Department.

18.

The Department specially reserves the right to permit oyster growers to remove such oysters and/or clam shells from any of said water bottoms or reefs within the area above described in this Contract as may be required by such oyster growers for seeding purposes only, and with which reservations LESSEES acquiesce and consent.

19.

LESSEES agree that in the event the Department shall desire to permit oyster growers to remove oyster and/or clam shells as provided, the Department will furnish to such oyster growers a written order to the aforesaid LESSEES authorizing and directing LESSEES to permit the removal of oyster and/or clam shells by said oyster and/or clam growers.

20.

The Department specifically reserves the right to establish rules and regulations on dredging areas in the interest of living resources and suspend the removal of shells and/or other shell deposits from the above described beds or water bottoms by LESSEES and their successors and assigns in the event that the dredging operations by LESSEES and their successors and assigns violate said regulations. The suspension aforesaid shall remain effective and in full force and effect for such duration or period of time as said dredging operations continue to be in violation of said regulations, cause or produce the damage or damages herein provided and until corrected by LESSEE, and its successors and assigns, to the complete satisfaction of the Department.

21.

No failure or omission by any of the parties hereto in the performance of any obligation imposed by this Contract shall be deemed a breach of this Contract or create any liability for damages if the same shall arise from any cause or causes beyond the control of such party and without the fault or negligence of such party, including acts of God, acts of Federal, State or local government, or any agency thereof, order or directive of any governmental authority or any officer, department, agency or instrumentality thereof, acts of the public enemy, war, rebellion, sabotage, insurrection, riot, invasion or strike. This force majure clause shall not apply to the annual minimum guaranty set forth in item 22 in any lease year in which any of the Purchasers dredge shells under the provisions of this agreement.

22.

The Department does give and grant unto each LESSEE, who has not lost or forfeited its rights hereunder, the right at any time to terminate this Agreement by each such LESSEE, who has not lost or forfeited its rights hereunder jointly, giving to the Department ninety (90) days' written notice of such LESSEE'S intention so to do, provided said written notice shall be accompanied by the payment of a termination fee in the sum of FIVE THOUSAND ($5,000.00).

Should this Agreement be terminated at any time other than the end of lease year, then the THIRTY THOUSAND DOLLAR ($30,000.00) annual minimum guaranty shall be reduced by the amount of royalty paid by LESSEES to the Department during such lease year, but prior to such termination, to the end that LESSEES in the lease year of termination shall pay not less than the THIRTY THOUSAND DOLLAR ($30,000.00) minimum annual guaranty. After making said calculation, should it be determined that any part of said annual guaranty shall be due and owing, then such amount shall be paid to the Department along with the FIVE THOUSAND DOLLAR ($5,000.00) termination fee.

The words "lease year", wherever in this item used, shall mean the period beginning on May 18th and ending on the following May 17th. The termination of this Agreement by LESSEES shall not relieve LESSEES of all LESSEES' obligations hereunder arising prior to the effective date of termination.

23.

The contractual rights of each respective LESSEE granted hereunder shall not be abridged by the failure of any other LESSEE'S failure to perform pursuant to this agreement except that the remaining LESSEES shall not be relieved of the obligation to pay the annual minimum guaranty provided in paragraph 22. Cancellation of this agreement as to said offending LESSEE or LESSEES shall in no way affect the other LESSEES or in any way change, alter or amend this Agreement as to them.

24.

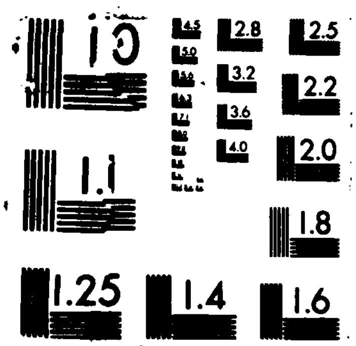
If any provisions of this Agreement shall be decreed invalid or unenforceable, the remainder of the Agreement shall continue in full force and effect.

25.

This document contains the entire agreement between the parties [illegible] cannot be changed or terminated orally but only by an agreement [illegible] writing and signed by the party against whom enforcement of [illegible] change, modification or discharge is sought.

AD-A181 854 OYSTER SHELL DREDGING IN ATCHAFALAYA BAY AND ADJACENT WATERS LOUISIANA DR (U) ARMY ENGINEER DISTRICT NEW ORLEANS LA G D GOEKE APR 87

UNCLASSIFIED F/G 13/2 NL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26.

The Department shall have the right to negotiate with the LESSEES or any of them for the planting of shells for oyster cultivation and to require the LESSEES to deduct the cost of such planting of shells from the royalties due the Department by such LESSEE. The LESSEES agree in good faith to negotiate with the Department for the planting of shells for oyster cultivation and the quantities and value of said shell shall be determined at the time of purchase.

APPENDIX C

PHYSICAL ENVIRONMENT

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APPENDIX C

PHYSICAL ENVIRONMENT

Introduction

The physical setting of the project area is diverse and the purpose of this appendix is to describe the physical processes which are involved within the coastal region where the proposed action is to occur. Because of the length of the sections and the detailed information contained herein, it is not feasible to present all of the background data within the body of the EIS. These data are included to allow the reviewer to form an opinion based on the most recent information available.

GEOMORPHIC HISTORY

Atchafalaya Bay is located within the Gulf Coast Plain Physiographic Province. This province is a region of low relief and represents a vest sedimentary basin which extends from Florida to Texas, and continues beneath the Gulf of Mexico forming the continental shelf. Exposed sediments, deposited in both marine and fluvial environments, generally dip gulfward at rates varying between one to five feet per mile at the surface, to 50 feet per mile in the subsurface. The oldest sediments deposited in the Gulf Coastal Plain are Cretaceous in age; however, surface deposits exposed within the immediate study area are Holocene in age. The present geomorphic features in the area owe their configuration to the combined effects of alluvial sedimentation, subsidence, and erosion within the last five to six thousand years.

The general study area, which parallels and is a part of the present Louisiana coastline, is underlain by a rather thick sequence of substratum sands which directly overlie Pleistocene materials. These deposits represent the materials brought into the area as the last glacial period period reached its peak. Approximately five to six thousand years ago, as sea level approached its present level, the first Mississippi River alluvial deposits began to enter the area as the Sale-Cypremont delta began forming east of the study area. Over the next several thousands years, the Mississippi River migrated back and forth across the central and southeastern area of what is now coastal Louisiana, depositing a massive wedge of alluvial sands, silts, and clays. Major deposition occurred in the study area about 3,500 to 4,000 years ago when the Mississippi River occupied the Teche Course and the Teche delta was forming in the study area, particularly in what is now the Terrebone Parish area. When the Mississippi River shifted eastward again, subsidence and erosion became the dominant processes in the study area and the formation of the typical irregular coastline was initiated. Subsidence, coupled with advancing gulf waters and subsequent coastal erosion, resulted in the formation of offshore barrier islands and numerous bays, tidal inlets, and low-lying coastal marshes. About 1,800 years ago, when the Mississippi River shifted

westward once again and occupied the Lafourche Course, alluvial sediments were deposited in the area. Since then, these factors have dominated the area, resulting in the present day irregular coastline configuration with barrier islands to the immediate east, and bays, tidal outlets, low-lying marshes, and exposed and buried beaches. Presently, the most prominent geomorphic features of the study areas are natural levee ridges north of East Cote Blanche, Atchafalaya, and Four League Bays; marshes to the west, north, and east of the study area; Point Au Fer Reefs to the south; and buried beach ridges within the marsh areas.

At present, sediment is being introduced into the study area by the Atchafalaya River; through both the Wax Lake Outlet and the Lower Atchafalaya River. The natural development of the Atchafalaya River has increased the amount of sediment deposited in the Atchafalaya Bay to the point that the river is now forming its own delta. In the 1950's, mud flats began to form along the central and western Louisiana coast, the result of the Atchafalaya flow. At present, this emerging delta is one of the dominant geomorphic processes occurring along coastal Louisiana.

The surficial sediments of the study area, to a large extent, are controlled by the influence of the fresh waters contributed by the Atchafalaya River and the Wax Lake Outlet. These rivers input tremendous amounts of river-borne materials into the basin every year. Calculations of Wells and Kemp (1982) indicate approximately 143,000,000 cubic meters of sediment are annually transferred into the system. Heavier, coarser-grained materials are dropped out of suspension at the mouth of the rivers where active delta formation is seen. Most of the finer suspended materials are carried farther away from the mouth of these rivers. This lighter material may be carried out toward the Gulf of Mexico where higher salinites of the open-gulf water cause flocculation and deposition. In any estuarine area, this flocculent zone would be found in a constantly shifting location. This is the case in the project area where wide swings in salinity regimes are commonplace.

Other factors also complicate the ultimate fate of suspended materials which get transported to the coastal zone. Storm Fronts which pass through an area have a tremendous impact on the resuspension and transport of materials. Waves generated by these storms, especially in as shallow a bay system as the project area, regularly resuspend tons of finer materials and rework much of the larger, coarser-grained sediments. Fine material not transported toward the Gulf of Mexico is generally carried along by prevailing current patterns and deposited farther west. Barrett (1975) reported this trend based in part on sediment data collected prior to the flood of 1973.

Barrett (1975) detailed surficial sediments of East Cote Blanche as dominated by clayey silts with large patches of clay and silty clay. Since that report, an additional detailed analysis of the sediments has not been performed, although supplemental data are available on development of mudflats in the coastal region. Wells and Kemp (1982) have presented information on the progradation of mudflats along the coast of Louisiana. Their report indicates that mudflats are building as the result of the "mudstream" produced by the inflow of the Atchafalaya River. The great majority of these mudflats form outside of the project area. This current of sediment-saturated waters carries an estimated 53,000,000 cubic meters of sediments annually. Although most sediment passes outside the boundaries of the bay system and nourishes the downdrift shoreline to the west or is dropped offshore, a portion remains within the system to build significant deposits. These mudflats are transitory and short-lived in many instances. However, some of the regions shoal dramatically and do eventually fuse with the shoreline. This natural process is episodic and tied to the annual flow of the rivers.

Water Column Water Quality

Data for the general water quality characterization in the project area of East Cote Blanche/Atchafalaya/Four League Bay are presented in Table 1. Descriptive statistics for four general water quality parameters measured at six sampling locations are shown. The sampling locations are listed below and are indicated on Figure C-1

SAMPLING STATION NUMBER	LOCATION
1	East Cote Blanche Bay at South Point
2	East Cote Blanche Bay 3 miles South-Southwest of Point Marone
3	Atchafalaya Bay at Wax Laake Outlet
4	Atchafalaya Bay at Eugene Island
5	Mouth of Four League Bay
6	Four League Bay at Blue Hammock Bayou

The Louisiana Department of Environmental Quality (DEQ) has established water quality criteria and water use classifications for surface waters in accordance with the Federal Water Pollution Control Act Amendments of 1972, which define the following designated water uses: 1) primary contact recreation, 2) secondary contact recreation, 3) propagation of fish and wildlife, 4) public water supply, 5) shellfish propagation, 6) agriculture, and 7) outstanding natural resource waters.

Atchafalaya Bay, as well as Four League and East Cote Blanche Bays, have been classified according to these water uses. Designated uses

TABLE 1

GENERAL WATER QUALITY

STATION	1	2	3	4	5	6
Water Temperature, °C						
Number of Observations	203	226	215	166	220	173
Mean	21.1	21.1	19.3	18.3	202	22.4
Range	3.5-32.7	3.5-32.0	2.3-31.9	4.2-31.6	4.2-33.7	3.3-32.7
Period of Record	5/73-1/81	5/73-1/81	4/73-1/81	4/73-1/81	4/73-1/81	4/73-1/81
pH, Field, Standard Units						
Number of Observations	188	210	201	137	197	169
Mean	8.01	8.02	7.78	7.73	7.94	8.14
Range	5.20-11.50	4.80-10.30	4.80-10.80	3.40-9.70	3.40-9.60	5.90-9.60
Period of Record	5/73-1/81	5/73-1/81	4/73-1/81	4/73-1/81	4/73-1/81	4/73-1/86
Dissolved Oxygen, mg/L						
Number of Observations	183	205	192	136	188	159
Mean	8.2	8.2	7.1	7.6	7.5	8.4
Range	4.2-12.1	4.2-12.0	3.2-11.4	3.4-13.3	2.6-12.1	3.6-125
Period of Record	5/73-1/81	5/73-1/81	4/73-1/81	4/73-1/81	4/73-1/81	4/73-1/81
Total Chloride, mg/L						
Number of Observations				3122		
Mean				2728		
Range				15-20075		
Period of Record				6/48-4/73		

include primary contact recreation, secondary contact recreation, and propagation of fish and wildlife. In addition to these uses, Atchafalaya and East Cote Blanche Bays have been designated for shellfish propagation. Table 2 lists the DEQ numerical criteria applicable to these areas. In addition to the listed criteria, bacterial standards have been established. The bacterial standards corresponding to the shellfish propagation designation are as follows: the median Most Probable Number (MPN) shall not exceed 14 fecal coliforms per 100 ml, and not more than 10% of the samples shall ordinarily exceed an MPN of 43 per 100 ml for a 5-tube decimal dilution test in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions. Although Four League Bay has not been designated for shellfish propagation, the bacterial standards for primary contact recreation apply and are as follows: Based on a minimum of not less than 5 samples taken over not more than a 30-day period, the fecal coliform content shall not exceed a log mean of 200 per 100 ml, nor shall more than 10% of the total samples during any 30-day period exceed 400 per 100 ml.

The area has been classified as "effluent limited" by the State of Louisiana. This indicates that water quality is meeting and will continue to meet water quality standards or that there is evidence that water quality will meet these standards in the future after the application of effluent limitations required by the Clean Water Act. Despite this designation, water quality standards have not always been met. Total coliform counts have exceeded the limits in Four League Bay consistently.

Average temperatures ranged from 18.3 degrees Centigrade at station 4 (Eugene Island) to 22.4 C at station 6 (Four League Bay at Hammock Bayou). The extreme recorded temperatures ranged from 2.3 C to 33.7 C. The state standard maximum temperature of 32 C was occasionally exceeded in Four League Bay. This was probably due to natural causes, which is acceptable under the state standards.

TABLE 2

Louisiana Department of Environmental Quality
Water Quality Criteria

	1	2	3	4	5	6
Area Description	Chloride mg/L	Sulfate (SO_4) mg/L	pH Range S. U.	Temp °C	Total Dissolved Solids mg/L	Dissolved Oxy mg/L
Atchafalaya Bay	N/A	N/A	6.5-9.0	32	N/A	5.0
East Cote Blanche Bay	N/A	N/A	6.5-9.0	35	N/A	4.0
Four League Bay	500	150	6.0-8.5	32	1000	5.0

Mean pH readings ranged from 7.73 at station 4 (Eugene Island) to 8.14 in Four League Bay. The extreme recorded readings ranged from 3.4 (Eugene Island) to 11.5 in East Cote Blanche Bay. Approximately 9% of the reading were outside the standards. Most of these were taken in Four League Bay where 20% of the reading exceeded state standards. Nearly all of the violations were exceedences of the maximum criteria. Mean dissolved oxygen (DO) readings were well above the state standards, ranging from 7.1 mg/l to 8.4 mg/l. However, there were infrequent measurements below the 5.0 mg/l state standard in Atchafalaya and Four League Bays. Approximately 4% of these readings were below the standards.

Chloride readings at Eugene Island ranged from about 15 mg/l to about 20,000 mg/l and averaged about 2,700 mg/l. This wide range in chloride readings reflects the influences of the Atchafalaya River and the Gulf of Mexico.

Pesticides and pesticide residues, nutrients, organic wastes, heavy metals, and other contaminants entering our waterways may associate strongly with particulate materials and eventually accumulate in the sediments. The presence of high levels of potentially toxic contaminants in some sediments has generated concern that shell dredging operations may cause the deterioration of the environment. Chemical residues which persist in the environment may be absorbed by plants and animals and accumulate within their tissues to levels that are greatly in excess of the ambient concentrations in their environment. Many of these substances have no known biological function and could accumulate to levels that are detrimental to the organism itself, or to its predators. Biomagnification may occur if the contaminant is persistent in biological systems and the food pathway is essentially linear, with the predominant energy flow from lower to higher trophic levels.

Although well known in terrestrial ecosystems, the occurrence of biomagnification in aquatic ecosystems is questionable and is the topic of considerable debate. The literature treating the bioconcentration of

contaminants by and the toxicity of contaminants to marine and freshwater organisms is voluminous, in contrast to that regarding biomagnification. The available information suggests that mercury, particularly methylmercury, may be the only heavy metal that biomagnifies significantly within aquatic food webs. Food is also an important source of copper, zinc, and selenium, all of which are essential trace elements for animal metabolism, as well as arsenic, chromium, lead, and possibly cadmium, which are not known to have any biological functions. These metals do not biomagnify, however. Organic compounds which appear to have significant potential for biomagnification include polychlorinated biphenyls (PCBs), benzo(a)pyrene, the naphthalenes, and, possibly, a few organochlorine insecticides, such as dieldrin, endrin, kepone, and mirex. Relatively little food-chain information is available for other organic compounds, however. The data available indicate that biomagnification of contaminants in freshwater and marine food webs is not a dramatic phenomenon. As the biological availability of contaminants from sediments should be similar regardless of whether or not these sediments have been dredged and placed in an open-water disposal site, it appears unlikely that the open-water disposal of dredged material from shell dredging operations will have any substantial environmental impacts.

Sediment Quality - Contaminants

Sediment composition is an indicator of sources of contamination from diffuse inputs that are not readily discernible as point sources. Also, one of the concerns of shell dredging's effect on water quality is the release of contaminants from the bottom sediments to the water column. Therefore, the determination of the composition of sediments to be

dredged is essential in assessing potential water quality impacts of shell dredging. Sediment data were collected in Atchafalaya Bay by the Corps of Engineers in October, 1976, at five locations indicated on figure C-2. Although these data were collected some time ago, they are useful in determining the composition of Atchafalaya Bay sediments subject to shell dredging. Sediment core samples were collected at all five sites. The sample at site 16 was taken in the center of the Atchafalaya River Navigation Channel to a depth of 50 feet, while the others were drilled to 20 feet. The core samples were collected from the surface to total depth at each site. Native water samples were also collected at the five sites in order to facilitate elutriate tests.

The presence of a constituent in the bottom sediment does not necessarily mean that this substance will go into solution and result in an adverse effect on the receiving waters. Among the factors that determine the effect of a chemical constituent of the sediment on the quality of the receiving waters, are the form of the constituent (which affects its toxicity and availability to biological communities), and the location of the constituent within the sediment structure. For instance, mercury can be either in its elemental or methylated form, the latter of which is more readily absorbed by the bloodstream. With respect to its locality in the sediment structure, the constituent may be dissolved in the interstitial water, adsorbed to the charged surfaces of the sediment particles, present as discrete particles, or as an integral part of the sediment organic fraction.

Elutriate tests were performed on all core samples using native water from each site. The elutriate test is a simplified simulation of the dredging and disposal process, wherein predetermined amounts of dredging site water and sediment are mixed together to approximate a dredged material slurry. It is a conservative estimate of contaminant release caused by the dredging process.

These core samples should be representative of the material dredged by the shell dredgers in the Atchafalaya Bay. The areal distribution of

the samples cover a large part of the permitted areas. Also, the depths of the core samples encompass the depths encountered in the shell dredging operations, and not just the bottom surface sediments.

Sediment quality data from the five core samples are presented in Table 3. Native water quality data from the same locations are shown in Table 4. Table 5 presents details of the elutriate data obtained from samples prepared from the native water and sediment core samples. "Zero" values in the tables indicate that the concentration of the particular parameter was less than the detection limits.

Concentrations of some parameters were greater in the elutriate samples than in the native water samples. This indicates that there is the potential that dredging could release these constituents into the water column. The concentrations of some of the constituents actually decreased in the elutriates. This indicates that the dredged sediments have the potential to "uptake" these constituents.

Dissolved kjeldahl nitrogen and chemical oxygen demand concentrations in the elutriate samples were higher than in the native water. This is probably due to the disturbance of organic material in the sediments.

Nickel, lead, arsenic, and cyanide concentrations in the elutriates were all either the same or greater than the concentrations in their respective native water samples. Although some elutriate concentrations of arsenic and lead are high, they are below EPA water quality criteria for freshwater aquatic life. However, the concentration at station 19 is slightly higher than the saltwater aquatic life criteria. Because of the variable salinity regime in this area, both the freshwater and saltwater criteria must be considered. Cyanide concentrations in the elutriates at stations 15 and 19 exceeded the saltwater criterion and the freshwater four day average criterion.

Chromium concentrations in the elutriate samples were higher than the concentrations in the respective native water samples at stations 15 and 18 and lower at stations 16, 17, and 19. All of these concentrations were below the EPA criteria, however.

TABLE 3

ATCHAFALAYA BAY WATER QUALITY DATA-BOTTOM SEDIMENT

LOCATION	SITE NUMBER 15	16	17	18	19
SAMPLING DATE	761015	761015	761015	761015	761015
NITROGEN, TOT KJD AS N (MG/KG)	2900	320	790	790	120
COD, (MG/KG)	6	2	4	3	1
CYANIDIE, (UG/G)	0	0	0	0	0
RESIDUE LOST ON IGNITION, (MG/KG)	42200	12800	28800	31800	4400
OIL AND GREASE, (MG/KG)	3000	0	3200	0	8100
ARSENIC, (UG/G)	11	6	8	7	2
CADMIUM, (UG/G)	<10	<10	<10	<10	<10
CHROMIUM, (GU/G)	<10	<10	10	10	10
COPPER, (UG/G)	15	<10	10	13	<10
LEAD, (UG/G)	<10	<10	<10	<10	<10
MERCURY, (UG/G)	0.05	0.02	0.05	0.02	0.00
NICKEL, (UG/G)	<10	<10	<10	<10	<10
ZINC, (UG/G)	50	25	40	40	20
ALDRIN, TOTAL (UG/KH)	0.0	0.0	0.0	0.0	0.0
CHLORDANE, TOTAL (UG/KG)	0	0	0	0	0
DDD, TOTAL (UG/KG)	0.0	3.4	4.4	5.8	0.0
DDE, TOTAL (UG/KG)	0.0	0.0	2.3	3.6	0.0
DDT, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
DIAZINON, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
DIELDRIN, TOTAL (UG/KG)	0.0	0.2	0.6	0.5	0.0
ENDRIN, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETH PARTH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETH TRITH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
ETHION, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
HEPT. EPOX, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
HEPTACHLOR, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
LINDANE, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MALATHION, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MET, PARTH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
MET, TRITH, TOTAL (UG/KG)	0.0	0.0	0.0	0.0	0.0
PCB, TOTAL (UG/KG)	0	0	0	0	0
PCN, TOTAL (UG/KG)	0	0	0	0	0
TOXAPHENE, TOTAL (UG/KG)	0	0	0	0	0

TABLE 4

ATCHAFALAYA BAY WATER QUALITY DATA-NATIVE WATER

LOCATION	15	16	17	18	19
SAMPLING DATE	761015	761015	761015	761015	761015
NITROGEN, DISS. KJD (MG/L)	0.41	0.49	0.58	0.48	0.52
RESIDUE, SUSPEN. 110C (MG/L)	17	16	12	16	22
RESIDUE, TOT. NONFIL, 105C (MG/L)	25	17	14	17	27
RESIDUE, VOLAT, SUSP. (MG/L)	0	0	0	0	0
CHEMICAL OXY. DEMAND (MG/L) (FILT. SAMPLE)	24	24	24	20	30
CYANIDE (MG/L)	0.00	0.00	0.00	0.00	0.00
PHENOLS (UG/L)	5	8	12	6	8
OIL AND GREASE (MG/L)	0.0	0.0	0.0	0.0	0.0
ARSENIC, DISSOLVED (UG/L)	1	1	2	1	1
CADMIUM, DISSOLVED (UG/L)	0	0	0	0	0
CHROMIUM, DISSOLVED (UG/L)	7	7	10	0	10
COPPER, DISSOLVED (UG/L)	5	2	3	3	4
LEAD, DISSOLVED (UG/L)	0	0	0	0	0
MERCURY, DISSOLVED (UG/L)	0.1	0.3	0.5	0.2	0.2
NICKEL, DISSOLVED (UG/L)	2	2	2	2	2
ZINC, DISSOLVED (UG/L)	20	30	30	20	10
ALDRIN, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
CHLORDANE, TOTAL (UG/L)	0.0	0.0	0.0	0.0	0.0
DDD, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
DDE, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
DDT, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
DIAZINON, TOTAL (UG/L)	0.01	0.00	0.00	0.00	0.00
DIELDRIN, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
ENDRIN, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
ETH. PARTH., TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
ETH. TRITH. TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
ETHHION, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
HEPT. EPOX., TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
HEPTACHLOR, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
LINDANE, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
MELATHION, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
MET. PARTH., TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
MET. TRITH., TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
PCB, TOTAL (UG/L))	0.0	0.0	0.0	0.0	0.00
PCN, TOTAL (UG/L)	0.0	0.0	0.0	0.0	0.00
TOXAPHENE, TOTAL (UG/L)	0	0	0	0	0
SILVEX, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
2,4-D, TOTAL (UG/L)	0.02	0.00	0.00	0.00	0.05
2,4-DP, TOTAL (UG/L)	0.00	0.00	0.00	0.00	0.00
2,4,5-T, TOTAL (UG/L)	0.04	0.04	0.04	0.04	0.06

Table 5 ATCHAFALAYA BAY WATER QUALITY DATA-STANDARD ELUTRIATE

LOCATION	SITE NUMBER 15	16	17	18	19
SAMPLING DATE	10/15/76	10/15/76	10/15/76	10/15/76	10/15/76
NITROGEN, DISS. KJD (MG/L)	9.7	2.0	0.65	1.7	1.3
CHEMICAL OXY DEMAND (MG/L)(FILT. SAMPLE)	52	46	42	42	39
CYANIDE (MG/L)	0.01	0.00	0.00	0.00	0.00
PHENOLS (UG/L)	2	6	13	1	2
ARSENIC, DISSOLVED (UG/L)	4	1	1	2	1
CADMIUM, DISSOLVED (UG/L	0	0	0	0	0
CHROMIUM, DISSOLVED (UG/L	8	0	0	8	0
COPPER, DISSOLVED (UG/L	2	3	3	2	4
LEAD, DISSOLVED (UG/L	0	0	3	0	2
MERCURY, DISSOLVED (UG/L)	0.3	0.1	0.1	0.2	0.0
NICKEL, DISSOLVED (UG/L)	2	3	3	3	8
ZINC, DISSOLVED (UG/L)	10	10	20	10	10

The mercury concentration in the elutriate sample at station 15 was higher than in the native water. All other elutriate concentrations were the same or lower than the respective native water concentrations. All the native water concentrations were above the four-day average criterion but below the one-hour average criterion for both freshwater and saltwater aquatic life.

Phenol concentrations in the elutriates were lower than the respective native water concentrations at all but one station. However, all concentrations were below the criteria.

Zinc concentrations were all below the criteria. The elutriate concentrations were all less than the respective native water concentrations.

Cadmium was not detected in either the water, sediment or elutriate samples.

In summary, the impacts of shell dredging operations on water column water quality are temporary and localized. Sediment data dealing with toxicity and bioconcentration of contaminants indicate that the open-water disposal of the sediments would not affect the quality of the water beyond the resuspension of material.

Sediment Physical Characteristics

The sediments of the permitted areas of Atchafalaya Bay, Four League Bay and East Cote Blanche Bay have been supplied primarily by the Atchafalaya River (Juneau, 1975). The uppermost sediment layers are fine-grained and remain unconsolidated, being subject to frequent resuspension by currents and windwaves. The upper sediments are mostly clayey silt, in the northern part of the Atchafalaya Bay, nearest the mouths of the Atchafalaya River and the Wax Lake Outlet. The predominantly westward drift of coastal currents in the area produce a grading of coarse to fine sediments from Atchafalaya Bay to East Cote

Blanche Bay. A similar coarse to fine gradient occurs from the distributary mouths southward toward the Gulf of Mexico. Four League Bay sediments are generally similar to those of Atchafalaya Bay (silty clay to clayey silt).

Since about 1839, the Atchafalaya River has tended to carry greater discharges than formerly, when upstream log jams had obstructed flows (Morgan et al., 1953). During the intervening period, three to four meters of new, predominantly clay and silt sediments have been deposited in the vicinity of Atchafalaya Bay. Extensive buried oyster shell layers have been found near the bottoms of these recent deposits. The Atchafalaya Bay had assumed a generally uniform depth by the early 1950's as the result of reworking of bottom sediments by waves and tidal flushing of suspended sediments. East Cote Blanche Bay and Four League Bay have also begun infilling relatively slowly with new sediments transported by coastal and tidal currents from Atchafalaya Bay.

The shallow water depths of the study area, averaging about 8 feet in East Cote Blanche Bay, 5 feet in Atchafalaya Bay, and 3 feet in Four League Bay, promote wind driven circulation patterns, which tend to maintain high suspended sediment and turbidity levels even during periods of low headwater discharge.

Turbidity is the optical property of water that causes light to be scattered and absorbed, rather than be freely transmitted. The scattering and absorption are caused by dissolved and suspended substances in the water, and are most directly related to suspended solids concentration, but also to sediment particle shape and size distribution, refractive index, color, and absorption spectra (Weschler and Cogley, 1977). Turbidity may be expressed in various units, depending on the method of measurement. Most turbidimeters in current use measure turbidity in terms of light transmission (transmissometers) or light scattering (nephelometers). Secchi discs are also widely used to measure depth of light penetration from the surface.

Turbidity levels at the Calumet and Morgan City water quality stations are commonly between 55 and 110 JTU (Jackson Turbidity Units) during high flow months, although values up to 200 JTU or more are infrequently attained (USACE). During the late summer and early autumn, turbidity levels of about 10 to 55 JTU are common (Figure C-3). Data presented in Juneau (1975) have also provided an indication of the high natural turbidity levels, as well as some indication of the amount of variation that occurs within the system . That work provided turbidity data for 5 stations from within the project area. These data have been averaged and are presented as Figure C-4.

Suspended sediment concentrations are highest during flood periods, when river currents are of sufficient velocity to erode stream banks and scour the stream bed. Soil particles remain in suspension until velocities become slow enough for gravity settling to occur. Much of the suspended sediment transported from the Atchafalaya River and Wax Lake Outlet into the bays remain suspended during high river discharges. Washoff of accumulated organic debris from the Atchafalaya Basin land areas during storms and headwater floods contribute significantly to observed turbidity levels, as does frequent resuspension of fine bottom sediments by wave turbulence. In a typical year, Wax Lake Outlet and Atchafalaya River suspended sediment concentrations might range from below 100 to above 500 mg/l with levels between 200 and 400 mg/l being commonplace (USACE).

It has been widely noted that during open-water hydraulic dredging and disposal activities, suspended sediment concentrations become greatly elevated in the immediate vicinity of the dredge intake (near the cutterhead) and the discharge pipe. Turbidity plumes are caused by clay and silt particles smaller than .03 mm (30u) and flocs (masses) of agglomerated particles that settle very slowly in the water column. Field investigations of the project area shell dredging operations in 1976 showed that both turbidity in NTU (Nephelometric Turbidity Units) and suspended sediment concentrations in mg/l were raised to several

hundred units near the dredge at the water surface (GSRI). Corresponding maximum near-bottom values were many times higher, in the tens of thousands.

The most pertinent operational factors in turbidity plume generation by shell dredges are the slurry solids concentration, the slurry discharge rate, and the discharge pipe configuration. The Dredged Material Research Program (DMRP) developed a predictive capability for the nature, degree, and extent of dredged material dispersion at dredging and open-water disposal sites. A series of reports were published in 1977 and 1978 describing the research results. Although these investigations were associated primarily with hydraulic pipeline and hopper disposal of navigation channel dredged material, the derived relationships are generally applicable to shell dredging operations in the project area.

The DMRP field observations consistently revealed that upper water column turbidity quickly decreased with distance from the disposal site as the result of vertical settling and horizontal dispersion. It was found that only about one to three percent of the discharged solids remained in suspension long enough to contribute to upper water column turbidity, the percentage depending primarily on the proportion of fine-grained material in the slurry (Nichols et al., 1978). The remaining material descends rapidly to the bottom where it becomes a low-to medium-density fluid mud mound. Sediment concentrations at the water/fluid mud interface are about 300 to 500 g/l at the bottom of the deposited layer.

A laboratory study of turbidity generation potential of clay and natural sediments was performed by the Walden Division of Abcor, Inc. for the DMRP (Weschler and Cogley, 1977). Turbidity was monitored as a function of time in waters of various salinity, hardness, and ph levels. Statistical analyses of the data were conducted to evaluate the relative importance of sediment properties and water composition to settling rates of the suspended materials. Turbidity was measured in terms of

percent light transmission, light scattering, and suspended solids. A single linear regression equation was determined to be statistically significant at the 1% level between the light attenuation coefficient and suspended solids concentration for both the clays and the natural sediments from 8 dredging sites. The determination coefficient, r2, of 0.84 meant that 84 percent of the variance in light transmission was explained by the suspended solids concentration. Somewhat poorer correlations were obtained when comparing the degree of light scattering with suspended solids (r2 values of 0.72 and 0.60 for the clays and the natural sediments, respectively). It is important to establish such relationships so that field and/or laboratory measurements of turbidity may be appropriately used to approximate suspended sediment concentrations, which are less easily measured than the light transmission or scattering properties of the water column.

The turbidity vs. time relationshps for three common clay minerals, kaolinite, illite, and montmorillonite, in fresh waters showed persistent high turbidity (low settling rates) for each mineral in soft water, but significantly faster turbidity reduction in hard water (200 mg/l total hardness). The montmorillonite samples and clay mixtures containing montmorillonite all experienced much more rapid turbidity reductions than the other clay samples in hard water. Solutions containing as little as 0.1 percent sea salt, i.e. one part per thousand (PPT) total salinity, induced greatly accelerated turbidity reductions compared to the fresh water, particularly for the samples containing montmorillonite.

Salinity levels greater than 5 ppt were found to have little additional influence on montmorillonite flocculation and settling. Nor were the settling rate differences between 1 and 5 ppt salinity solutions as great as between those samples which did or did not contain montmorillonite. Although pH appeared as a significant influencing variable in the regression analysis, it was concluded that this occurred because the salty and hard waters were always basic in the tests, and that the pH factor actually reflected the salinity and hardness effects. A limited number of tests made with low concentrations of silt, which

does not tend to flocculate, showed little effect on the observed turbidity reduction rates attributable to clays, indicating little or no interaction between clay and silt.

The eight natural sediments tested included four each from freshwater and estuarine dredging sites. The Mobile Bay sediments were probably most similar to those sediments encountered in the project area with regard to moisture content and particle size, although they were somewhat coarser than the silty clays most prevalent in the shell dredging areas. Comparative tests of the natural sediments were made to relate differences in settling behavior to sediment composition characteristics at 1,000 mg/l initial concentration in 1 ppt salt solutions, both in terms of absolute turbidity values and after normalization to the initial turbidity.

The organic content was found to be the predominant compositional factor affecting natural sediment settling rates, with the higher organic levels responsible for more rapid turbidity reduction. The proportion of montmorillonite to other clay minerals was found, however, to be an unimportant factor for the natural sediments. Two possible explanations were suggested for this, the first being that the overwhelming importance of organic carbon in affecting settling behavior tends to mask the clay mineral properties. The second possibility is that the particular montmorillonite sample that was tested may have behaved as it did not only because of its mineralogy, but perhaps also because of its much finer particle size or some other factor. Regardless, the tests showed that clay mineralogy is less important in the settling behavior of natural sediment than other factors.

Initial sediment concentrations also were an important factor, with the high initial concentrations leading to more rapid turbidity reduction. This may have been due to more frequent particle collisions, or to increased organic matter concentrations, or both in the more concentrated sediments. Although the silts generally settled independently as expected, it was found that significant differential

settling of the various clay sizes did not occur. This also suggested the important role of organics in promoting complex aggregate formulations of clay and organic matter after induced flocculation by water hardness or salinity.

The analytical results were used to develop a turbidity plume computer model which yielded favorable comparisons with available field data in Mobile Bay. Such a model could be developed for the project area sediments using laboratory jar tests with native water, and field measurements for verification and refinement. If enough field data were collected under varying wind and current conditions, the model could be made more generally applicable. The research conducted with the eight natural sediments showed that turbidity plumes are largely predictable from knowledge of sediment properties, but that hydrodynamic factors controlled by winds and tides are nevertheless important. Dredge movement with respect to prevailing currents is also an important determinant of turbidity dispersion characteristics. Other factors, including turbulent mixing in the discharge pipe and homogeneity of the discharged material, may also be important factors in turbidity generation and reduction, but have not been studied sufficiently to form definite conclusions.

Schubel et al. (1978) developed a relatively simple method for predicting turbidity plume characteristics based on a theoretical hydraulic mode. This plume model has been verified and refined using field data collected at three open-water pipeline disposal operations in estuaries. The input parameters are dredge discharge rate, water depth, average current velocity, mean particle diameter or settling velocity, an estimate of diffusion velocity, and the age of the plume, which is dependent on the tidal type (diurnal or semi-diurnal) and/or longitudinal current velocity in the case of a river. Given these six parameters, ratios and scaling factors can be developed and applied to a series of nomographs to estimate vertically averaged suspended solids concentrations along the plume centerline with respect to distance from the discharge location. After dredged material discharge ceases, the

suspended material will settle and disperse laterally, with the visual near-surface plume usually disappearing after one to two hours (Nichols et al., 1978). Depending on depth, settling velocity and diffusion velocity, the subsurface plume may persist considerably longer. Schubel et al., (1978) also gives a method for estimating plume concentration decrease with time as a function of settling and/or diffusion. The plume model is not capable of compensating for particular wind and wave conditions.

At this time, there are no known sets of dredge discharge condition data, including solids content of the slurry, comprehensive water column turbidity plume measurements, and corresponding settling velocity determinations of bottom sediments, available from the study area to verify an existing predictive model against. Nor are either of the referenced plume models presently capable of simulating a moving discharge source, or correcting for wind-induced turbulence. A well-conceived data collection and model verification program would be required to achieve acceptable predictive capability of plume conditions for shell dredging operations in the study area.

The laboratory jar-test procedures are particularly important. The Abcor, Inc. report (Weschler and Cogley, 1977) recommended that the test sediments first be dispersed in the disposal site water during a 30-minute rapid mix period, followed by monitoring of the light transmission as settling occurs. The system must be calibrated to read 100 percent transmission in pure water. Initial concentration of the test sediment is important, since it seems to significantly affect the settling rate. Predicted turbidity plumes can be generated from jar-test data following the report's outlined procedures, using the referenced computer model. The data would first be converted to a settling velocity distribution, then entered into the computer model along with the water depth and current velocity. To adequately model a range of dredging sites, various input conditions should be run using data from several jar tests of different sediment samples, with initial concentrations corresponding to slurry concentrations in the discharge pipes of the

dredge(s) operating in that area. A range of discharge configurations, depths and current velocities might also be run to represent given field conditions. If a sufficiently comprehensive range of site and sediment conditions were modeled, the data could be reduced to a series of graphs, as was done for the Schubel turbidity plume model.

The referenced 1976 surveys of turbidity plumes near dredges in the study area were conducted in May, August, and November by Gulf South Research Institute (GSRI) (1977). Turbidity and suspended solids (SS) were measured near the surface and bottom of the water column at distances of 100 to 2,600 feet from each dredge along radials extending outward at 60 degree intervals.

During the sampling of May 13, the dredge discharge was to the south, the current was toward the southwest, and the wind was from the south. There was high wind activity at the time. The maximum observed surface turbidity level was 750 NTU at 100 feet to the south (180 degree azimuth). At 200 feet south, however, a near normal level of 155 NTU was measured. The farthest extensions of high turbidity levels were measured along the 240 and 300 degree azimuth (west of the dredge) with 200 NTU occurring at distances of 1,000 and 800 feet, respectively (Figure C-5). The maximum surface SS concentration was 1,720 mg/l at 100 feet on the 180 degree azimuth, with 485 mg/l being measured at 800 feet along the 240 degree azimuth.

On August 19, the dredge discharge was to the south, the current was toward the southeast, and the wind was from the northwest. The maximum surface turbidity observed was 370 NTU at 200 feet along the 180 degree azimuth. Measured values were no higher than 80 NTU elsewhere (Figure C-6). The corresponding maximum SS value was 1,640 mg/l, with no other measurement higher than 320 mg/l.

The third turbidity survey was conducted on November 10. The dredge discharge was to the southwest, the current was toward the west-northwest, and the wind was from the southeast, and extremely calm.

Surface turbidity was a maximum of 1,050 NTU at 100 feet along the 60 degree azimuth, but the highest turbidity level observed at a distance of 200 feet was 175 NTU along the 180 degree azimuth (Figure C-7). The corresponding SS levels were 5,100 and 670 mg/l.

The measured near-bottom turbidity and SS data were considered generally unusable as indicators of plume extent because the bottom samples often contained disturbed bottom sediments. The sampling scheme, i.e., observations along each 60 degree radial from the dredge, was less likely to have included the actual plume centerline the greater the distance from the dredge. It is possible the maximum reported values are at variance with the true maximum values. The limited available data and the complexity of the physical processes do not permit a definitive analysis. Had samples been taken at intermediate depths, more inferences could have been drawn about settling rates and dispersion characteristics. The grain size, bulk density, and other physical properties of the sediments which affect settling behavior were not given.

May (1973) reported on the effects of hydraulic dredging in Mobile Bay, Alabama, with plume sampling at three dredging sites on a number of occasions in 1971, 1972, and 1973. Most of the sampling data were obtained from the shell dredge Mallard, which had a total pumping capacity of 41,000 gpm, and which had an average production rate of about 300 cubic yards of oyster shell per hour. The sediment overburden in the shell dredging areas of Mobile Bay was mostly clay and silt, except within the six-foot contour nearer shore, where sand fractions were high. When overburden material is composed primarily of coarser particles, they are deposited in the immediate vicinity of the discharge. Particles less than about 62 u may be transported within the fluid mud flow.

On a very windy day, surface and mid-depth turbidity did not exceed the ambient level of 50 JTU beyond about 400 feet from the discharge in any direction or beyond 200 feet in most directions. On a calm day,

ambient or annual average (23 JTU) turbidity levels were not exceeded at distances beyond 400 feet.

In October 1972, turbidity was measured downcurrent and downwind, on a falling tide. Wind speeds ranged from 7 to 13 knots. Samples were taken out to 5,000 feet from the discharge, but the surface turbidity plume was visible for about 5,000 feet beyond that distance. Levels of 90 JTU were exceeded as far as 800 feet from the discharge, and the annual average level was slightly exceeded beyond 5,000 feet. Under normal conditions, dredging plumes cannot move farther than the tidal movement in a 12-hour period, since the flow direction of the water mass reverses at the end of a tidal cycle. The distance would normally be about 3.6 nautical miles, but winds and river discharges are known to have significant influences on water movements and the actual distance would be different.

The horizontal distribution of suspended solids was determined on a relatively calm day and on a very windy day. On the calm day, SS levels at the surface were less than 100 mg/l, except within 400 feet of the discharge. At distances greater than 1,200 feet, the levels were less than the 27 mg/l annual average for the bay. Mid-depth SS levels of 100 mg/l or more were measured up to 800 feet from the discharge, and ambient concentrations were exceeded out to 2,000 feet in some directions. The combined average SS level of all samples between 200 and 800 feet from the discharge was 60 mg/l, or less than 0.1 percent of the averaged bottom samples over the same distances. Within 100 feet of the discharge, the average surface concentration had become reduced by 98.5 percent, and the mid-depth concentration by 91.0 percent. Over 90 percent of the solids had fallen directly to the bottom under the discharge, and about 96 percent had settled within 200 feet.

Almost all of the settled material from the dredge discharge became a distinct density layer of fluid mud. Between 100 and 200 feet from the discharge, SS concentrations within the layer had significantly increased because of consolidation. Most of the mud was moved by gravity as a

density flow. The surface layer of fluid mud with a density of 100 mg/l or greater extended to a maximum distance of 1,000 feet from the discharge.

On the windy day, samples were collected at 0.5 and 2.0 feet above the bottom to determine the effect of wind mixing on the density flow. Suspended solids concentrations greater than 1,000 mg/l were measured in the upper samples up to 2,000 feet from the discharge. Near the bottom, mud concentrations as high as 22,000 mg/l were measured up to 1,600 feet from the dredge. The SS concentrations were almost twice as high from east to west along a line 1,200 feet south of the dredge as they were along a north to south line from the discharge out to 1,600 feet. Concentration levels observed farther than 2,000 feet from the dredge did not greatly exceed background values.

The extent of wind mixing was apparent from observed salinity and temperature fluctuations and inversions. The wind energy was determined to have caused the solids to remain in suspension longer, thereby extendingthe horizontal distance traveled before settling. Higher concentrations also occurred in the fluid mud at greater distances from the dredge. Wind-induced turbulence caused bottom concentrations beyond the limits of fluid mud flow to be above background levels for a greater distance. A flocculated density layer with SS levels of 1,000 to 4,000 mg/l was maintained over a larger area than under more normal conditions. This reflected the higher boundary concentrations in the fluid mud, and a higher energy for suspension.

It should be noted that shell dredging, as practiced in Mobile Bay during these surveys, did not usually entail the removal of nearly as much overburden material as is common in the project area. Thus, the surface area covered by a dredge in Mobile Bay within a given time period would probably be greater than that in the bay area. The average degree of consolidation of the dredged material taken from nearer the surface would probably be lower for sediments of equivalent grain sizes.

The four sediment cores taken from the vicinity of the Mobile Bay shell dredging field surveys were classified as: sand; clay silt; and silty clay (two samples). The corresponding averaged organic carbon content levels, in percent dry weight, were 0.3, 1.3, and 1.9 percent. These variances in sediment characteristics would have significantly influenced the manner of dispersion and deposition of the dredged material, along with slurry discharge rate, currents, and turbulence in the water column. Given these uncertainties, and the relatively greater levels of uncertainty associated with the referenced GSRI shell dredging investigation in the bays area, the reported results of each study should be viewed as more or less generally indicative of the ranges of turbidity plume effects to be expected, but not necessarily representative of particular combinations of conditions. More complete site-specific sediment characterizations and definitions of background suspended sediment and hydrodynamic conditions would be needed to obtain a reliable predictive capability for potential project area turbidity levels caused by shell dredging.

Oyster shell dredges move relatively slowly, compared to the speed of the clam shell dredges in Lake Pontchartrain, and thus have only a minor influence on the dispersion behavior of turbidity plumes. Other factors being equal, an oyster shell dredge's turbidity plume should therefore be more intense near the dredge, and the pattern of its expansion should be more uniform than that generated by a clam shell dredge, which moves in an irregular fashion.

Within minutes after dredging ceases, surface turbidity at the site will normally decrease to near background levels unless salinity is well below one ppt. Even under fresh or nearly fresh conditions, which may occur during high flow periods, the naturally high hardness levels of the water, averaging 300 mg/l or more (USACE, 1985), will nevertheless promote some degree of flocculation and settling of fine particles. Subsurface turbidity will continue for longer time periods and at greater distances from the dredging site, even after dredging ceases. The ultimate plume dimensions and intensity gradients will be directly

determined by the currents within the water column, which may be highly variable both in speed and direction.

Under quiescent conditions, the plume will expand slowly and remain more highly concentrated than under windy, turbulent conditions, when it affects a larger area but becomes less intense. The degree of turbulence and the current speed also act to retard settling times of fine sediments, keeping them in suspension over longer distances from the dredging sites. Water depths ultimately limit the extent of subsurface plume travel.

The rapid deposition of the greater portion of the discharged materials as a dense conglomoration of sediment, shell, entrained water, and gasses is probably of greater ultimate consequence to the ecosystem than is the relatively widely dispersed turbidity plume, which can be readily observed. The most commonly-employed term for the dense masses of recently settled dredged material is fluid mud. Although the fluid mud mass quickly settles to the bottom, it may tend to remain concentrated near the point of deposition or may spread outward over a wide area.

The above-referenced DMRP program included a field investigation of fluid mud dredged material and its relationship to water column turbidity (Nichols et al., 1978). The study objectives included observation and measurement of the nature, extent, and thickness of fluid mud in relation to its source and to turbidity at several open-water pipeline disposal sites. Other objectives included measurement of water currents and fluid mud movement, and determination of the physical properties of the mud that affect its dispersal, stability, and persistence with time.

The measurement of fluid mud characteristics requires highly specialized equipment, particularly during the dredging operation. Water column turbulence is caused by the dredge discharge and propeller wash, and near the bottom by the dredge intake and cutter head. Natural water movement and turbulence results from tidal currents and wind-induced

waves, and constantly varies with time. The fluid mud immediately begins to consolidate upon settling to the bottom, and to move away from its initial location in response to gravity and bottom currents.

The referenced field investigation used specially designed and constructed sensing apparatus for _in situ_ measurements of the fluid mud at two sites, including Mobile Bay, Alabama. This was necessary because of the physical disturbances of the mud that would occur if samples were retrieved and processed in a laboratory. The sensors measured sediment density, turbidity, and current speed with depth. A dual-frequency fathometer was used to locate and record the approximate positions of the fluid mud surface and base, at a density of 1.30 g/cc. Water samples were taken for gravimetric analysis of suspended sediment and salinity measurements. Short core and grab samples were obtained for analysis of the physical properties of the mud. Field measurements were made before, during and after dredging operations, and under various hydrometerologic conditions. The following sediment parameters were measured in the laboratory: organic carbon, grain size, dry density, bulk (wet) density, water content, liquid and plastic limits, suspended sediment concentration, and shear strength. The void ratio and porosity were derived from the measured parameters.

The Mobile Bay open-water disposal site was in water depths of 3.0 to 3.8 m (about 10 to 13 ft). The wave energy regime was generally low during the field investigation. The mean tide range was 1.5 ft and the maximum tidal current was 1.4 ft/sec. The water column was characterized as relatively well mixed, with a salinity range of 0.09 ppt at the surface to 2.7 ppt at the bottom. Ambient suspended sediment concentrations were about 40 mg/l.

The 15 analyzed sediment samples included both freshly dredged material and older consolidated sediment, which may have consisted of previously dredged material. Most of the samples were classified as silty clay, with a mean size of 3.2 u. There was no observed distinction

in texture between the old and new sediment. The silt-clay ratio averaged 30:70, with sand occurring in only two samples at two percent or less.

The freshly dredged material and older consolidated sediments were compared with respect to their plasticity. The liquid limit was considerably higher on the average in the new material, and the plastic limit was somewhat higher. These differences, particularly for liquid limit, indicated the greater propensity for movement (flow) of the newer material.

The organic content of the samples averaged 1.96 percent, no distinction being made between the old and new sediments. Organic matter and its particular form significantly influences engineering properties of sediments. Rashid and Brown (1975) showed that addition of four percent humic acid to a muddy sand increased its plasticity and remolded shear strength, and almost doubled its liquid and plastic limits. The rate of consolidation of the altered samples decreased, however, as did their rate of permeability. The Mobile Bay sediments evidenced these characteristics.

The Mobile Bay sediments were classified as active clays, according to a direct linear relationship between the plasticity index and the percent of clay fraction finer than 2 u, defined by Skempton (1953). Activity refers to the increased surface activity of the clay fraction of a sediment, e.g. the increased ion exchange capacity and adsorption of water with decreasing grain size. The Mobile Bay sediments are predominantly montmorillonite, with kaolinite occurring in a lesser abundance (about a 4:1 ratio). The high montmorillonite content was responsible for the high liquid limit values of the freshly dredged material. Because of the relatively greater surface area of montmorillonite, larger amounts of water are attracted to the particles as both adsorbed and free water. The average water content of the sediments (before dredging) was 165 percent dry weight, and the bulk density was less than 1.3 g/cc.

The foregoing descriptions of Mobile Bay dredged sediment properties are given for the purpose of comparison with properties of sediments in the project area, and for characterizing their behavior as fluid mud masses after initial depositon. Five bottom sediment cores taken from permitted zones of the coast area were analyzed by the USACE Waterways Experiment Station in 1985 (Figure C-8). Bulk density profiles were determined for each of the samples, grain size distribution was determined for four samples, and one sample was subjected to a laboratory settling test. The sample depths were between 0.6 and 1.0 feet below the surface. The bulk density values were slightly variable with depth and location, averaging 1.55 g/cc at the surface and 1.62 g/cc overall, or considerably higher than the average density of the Mobile Bay sediments (less than 1.3 g/cc).

The textural composition of each of the samples was somewhat variable with depth, but about evenly distributed between clay and silt for the cores at the head of Four League Bay and in eastern Atchafalaya Bay. The upper Atchafalaya Bay sample between the two distributing channels was predominantly silt, with some clay. The central Atchafalaya Bay sample was silt and clay with some sand, and the East Cote Blanche Bay sample was silty clay. These general sediment type classifications are based on the qualitative descriptions that are currently available for the samples, and also on the sediment-type distribution maps prepared by LDWF (Juneau, 1975). At this writing the results of the laboratory analyses of grain size distribution and the settling column test for the upper Atchafalaya Bay sample are not available.

The bulk density of a sediment varies inversely with its water content, and is also affected by its organic content and shell content. Sediments that are dredged and redeposited in open water undergo a process of differential settling and reconsolidation. The upper layers continue to flow with gravity and tidal or riverine currents as fluid mud, but at a bulk density of about 1.13 g/cc, corresponding to a concentration of 200 g/l, the process of reconsolidation begins (Barnard, 1978). A thin surface layer of unconsolidated, low density sediments

exists throughout most of the study area, as the result of their frequent agitation by wind-wave turbulence and currents in the shallow waters of the bays.

The oyster shell dredging procedure assures that most of the discharged slurry material falls back into the dredged cut, which is ordinarily several feet below the adjacent waterbottoms. This sediment begins to consolidate more readily than the finer discharged material which settles beyond the dredged area. Although consolidation reduces the volume and elevation of the original redeposited material, the dredged cuts nevertheless become filled in with bed sediments transported by riverine and/or coastal currents from surrounding areas. The relative rates of infilling at dredged cuts in different parts of the permitted area are discussed elsewhere.

The fine-grained sediments that settle outside of the dredged cut consist of relatively thin layers of fluid mud. The ultimate distances of travel of these sediments are dependent on hydrodynamic conditions and physical properties of the sediments, particularly grain size and plasticity. The reconsolidation rates will be a function of hydrodynamics, these properties, and organic content of the sediments, which influences interparticle bonding and adsorption of water. Although direct measurements of organic carbon in the Atchafalaya Bay area sediments are not available, it is known that the Atchafalaya Basin exports large amounts of nutrients and fixed energy in the form of organic carbon to the estuarine area (Hern *et al*., 1980).

Turbidity caused by wind-wave turbulence is a function of wind speed and duration of sustained high wind speeds over open water areas. Frontal passages and storms are the phenomena that are most likely to produce sustained high wind speeds. Sheng and Lick (1979) related the incipient motion of bottom sediments (resuspension) to the bottom shear stress coefficient, which is a function of the physical properties of the sediments. Bottom stress due to wind-generated waves is related to wave

characteristics (height, period, length) and water depth. The shear stress coefficients of the project area bottom sediments have not been determined.

Sediments that have high organic content tend to consolidate more slowly than other sediments, but also tend to develop higher shear strengths (Nichols et al., 1978). Shear strength of bottom sediment is indicative of its frictional resistance to resuspension by currents or turbulence in the water column.

The highly visible near-surface turbidity plumes are caused by clay and fine silt in the discharged slurry. Even under fresh or near-fresh conditions, flocculation would normally occur to some degree, and vertical settling of the clays as agglomerated masses would begin to reduce upper water column turbidity levels.

The position of the end of the discharge pipe affects near-surface turbidity. If submerged and directed vertically downward, visual near-surface turbidity would be less than if discharge occurs above the surface or is directed outward (horizontally). The dredges currently active in the bays discharge above the water surface in a horizontal direction.

As described previously, once the initial momentum imparted by the force of the discharge and movement of the dredge has been depleted, all of the characteristics of the turbidity plume are controlled by currents and turbulence in the water column. Water column turbulence prolongs suspension times of discrete sediment particles, but also increases the frequency of interparticle collisions, thus promoting floc formation and faster settling rates. Higher current speeds produce a longer, more narrow turbidity plume than slow currents that produce a more rounded plume which eventually covers a larger surface area. The migrating plume proceeds in the general direction of the prevailing currents and slowly descends through the water column until it impacts the bottom. The shallow water depths in the permitted area thus control, to some degree,

the distance of travel of the turbidity plume. The dredge site location with respect to riverine and tidal circulation pathways greatly influences the shape and size of the turbidity plume that is generated.

The sediments containing the highest percentages of clay and fine silts produce the most dense and persistent turbidity plumes, with generally no more than three and perhaps less than one percent of the discharged slurry solids actually contributing to the plume. According to the DMRP studies, clay mineralogy and organic content affect flocculation rates and settling times, with organic content having the greater relative influence. In general, higher organic levels in sediments produce more rapid turbidity reduction (increased settling rates). Organic levels in the project-area sediments are believed to be relatively high compared to other locations.

The impacts of oyster shell dredging on turbidity levels should be considered in light of other important influences, namely high suspended sediment concentrations during seasonal high water periods (Figures C-3 and C-4), and bottom sediment resuspension caused by wind-wave turbulence and by tidal currents in some areas. Within about 500 feet of an operating dredge, near-surface turbidity levels are typically reduced to about 1,000 NTU or less, and corresponding suspended solids concentrations will become reduced to about 2,000 mg/l or less. The actual maximum turbidity levels that are generated depend primarily on the discharged slurry solids concentration, particle size distribution, discharge pipe configuration, water column turbulence and currents, and sediment organic content. If the salinity level is about one ppt or greater, flocculation of the fine clays will be considerably more rapid than under fresh or practically fresh water conditions. Maximum turbidity levels within the plume tend to diminish exponentially with distance from the dredge, and also occur gradually lower in the water column with distance as gravity settling continues. Maximum areal limits of the plume are dependent upon currents and water depths.

Long-term turbidity impacts from shell dredging are difficult to assess, but are considered to be inconsequential because of the limited amounts of affected area at particular times, and the physical processes which produce dispersion and settling of the suspended material. It is believed that any long-term residual increases that might occur after dredging would be very minor and inconsequential, especially with respect to naturally-occurring background turbidity levels.

The phenomenon of fluid mud generation by open-water dredging and disposal activities has been described in the preceding pages. It has been concluded that all but a minor portion of the discharged solids would be immediately returned to the dredged cut and remain there, initially as a soft, fluid mass, particularly in the uppermost layers, that moves in response to gravity and bottom currents. As time passes, the fluid mud begins to consolidate first in the lower, most dense layers and then sequentially in the upper layers.

Bottom sediments are moved from outlying areas by natural circulation processes to gradually fill the dredged holes. Consolidation of the originally deposited dredged sediments is accelerated as infilling occurs, applying additional weight and pressure to the underlying material. The rates of reconsolidation and infilling of the dredged holes can be determined by field measurements over periods of months to years. It is estimated that up to several years might be required to completely refill some of the deeper holes, particularly in zones of slower circulation.

The discharged sediments that settle outside of the dredged area behave initially as fluid mud, and continue to flow laterally until their density and frictional forces are sufficient to withstand further movement by bottom currents. A thin upper layer of the sediments will remain subject to occasional resuspension by currents and turbulence. The final contours of the dredged material outside of the dredged area should be in the form of thinly spread layers that extend outward from the dredged area to distances in each direction more or less proportional

to the prevailing bottom current fluxes and bottom elevation gradients. It is to be expected that the new material would reasonably soon become incorporated with the original material and thus become indistinguishable as a separate soil mass.

The phenomenon of fluid mud generation by open-water dredging and disposal activities has been described in the preceding pages. It has been concluded that all but a minor portion of the discharged solids settle out of the water column within the first 200 feet. The remaining, finer-grained material will travel away from the discharge location, but the turbidity generated will affect only a small percentage of the permitted area at any one time and probably would not contribute to long-term turbidity increases.

Land Loss

The Louisiana Central Gulf Coast area, comprised of East Cote Blanche Bay, Atchafalaya Bay, and Four League Bay,is an area in a state of change. In terms of land loss and coastal erosion, the Project Area varies from severe land loss in the eastern portion of the Terrebonne Marsh to near equilibrium conditions in East Cote Blanche Bay to land gain in the Atchafalaya Bay (Figure C-9). All of this occurs in an area of roughly 900 square miles. Since this area is in a state of flux, historical data have to be scrutinized carefully to see if the data are pertinent to the present situation.

The long term natural causes of land loss are compaction of sediments, subsidence, sea level rise, and erosion (Adams et al., 1976; Craig et al., 1979; Bahr et al., 1893). Mankind has helped to accelerate these processes throughout most of coastal Louisiana. Between 1895 and 1975 there was little change in depths of East Cote Blanche Bay. There has been a recent infilling of the tidal passes in the shoal area between South Point on Marsh Island and Point Chevreuil south of Bayou Sale Bay. Gradual infilling of East and West Cote Blanche Bays should be expected because of the direct impacts of sediments emanating from the Atchafalaya Bay. Tidal circulation into this area from Atchafalaya Bay is pronounced throughout the year. Wind driven tides are especially pronounced in the spring during high discharge periods.

Land loss increases eastward from the Atchafalaya Bay to Terrebonne Parish. Terrebonne Parish has experienced land loss rates of 8 square miles/year between 1955 and 1978 (Wicker et al., 1980). Preliminary results of a model study by Waterways Experiment Station indicated pronounced variabililty in land loss in the Terrebonne marshes in the areas affected by the Lower Atchafalaya River. Areas of the Terrebonne marshes immediately east of the Lower Atchafalaya River in the vicinity of Bayou Chene and the Avoca Island Cutoff channel show positive deposition rates due to sediments from the Atchafalaya Basin Floodway system.

The land surrounding Four League Bay also has positive deposition rates, while the remaining portion of Terrebonne Marsh has experienced land loss. However, the upper half of Four League Bay increased approximately 3% between 1956-1978. The rate of loss is dependent on circulation patterns and the presence or absence of backwater flows from the Atchafalaya Basin Floodway system.

Underwater contours for Four League Bay have remained stable over the period 1956-1978. Infilling of this area is expected to occur with time in a manner similar to East and West Cote Blanche Bays.

Holes/Troughs from Shell Dredging

In order to determine existing conditions as they relate: (1) to the source of the sediments which refill the holes/troughs resulting from past and current dredging operations in Atchafalaya Bay; and (2) rates at which these holes/troughs are refilled; and (3) the possible future effect the refilling of these holes/troughs may have on the future of the emerging/advancing delta from a consolidation/settlement standpoint, a series of vibracore borings were made by the U. S. Army Corps of Engineers, New Orleans District. The borings were made on 15 and 16 October 1986. The borings were classified in the field by a Corps geologist; samples were subjected to the normal series of geotechnical laboratory tests; and selected samples were tested for foraminiferal content and analysis, X-ray Diffraction (XRD), and Energy Dispersive X-Ray (EDX). Results from these borings and sample testing indicate generally that: (1) in the area west of the emerging Atchafalaya Delta, where shell dredging activities are currently active <Area I>; (2) in the area southwest of the emerging Atchafalaya Delta where shell dredging occurred in 1978 <Area V>; and (3) in the area south-southeast of the emerging Atchafalaya Delta where shell dredging occurred in 1981/1983 <Area VI>, the primary source of the sediments which refill the holes/troughs resulting from the shell dredging activities is the surrounding bay bottom, marine, and prodelta sediments in the immediate vicinity of the dredged areas. The foram and XRD/EDX analyses indicate a

depositional environment. A comparison to the foram and XRD/EDX analyses made on samples taken in the immediate vicinity-to the west <Area II>, south <Area IV>, and east <Area III>-of the emerging Delta and mouth of the Atchafalaya River, indicates a marked difference. Generally the samples from Areas II, IV, and III indicate abundant sediment supply; good mixing and oxidation of sediments; and forams indicative of active delta and delta front areas.

The rate of refilling was best demonstrated by the borings/samples taken in Area I where current shell dredging activities were occurring. A boring taken in the center of the dredge cut within 8 to 10 hours after a passover by the cutter head indicated 7.0 feet of water, as compared to 4.5 feet of water at the north outside edge of the cut. A 1.5 foot layer of highly fragmented shell and shell fragments was located at the bottom of the cut/top of the boring; underlain by 0.7 feet of non-laminated silt, silty sand with several large shells. These sediments were in turn underlain by non-stratified vSo and So Clays with shell and shell fragments to a total depth of 5.2 feet. Below this depth, the material consisted of So to Med highly stratified clays with organic material to a depth of 8.2 feet where Med highly stratified peat with layers of clay was encountered. The peat extended to a depth of 11.4 feet where a layer of Med highly stratified clay with a trace of organic was encountered. This clay material extended to the bottom of the boring which was 12.4 feet. The presence of the highly stratified clays and peats below 5.2 feet is a confirmation of the dredged depth to 12 feet below water surface. Since the total dredged depth was 12 below water surface (original water depth was 4.5 feet), or 7.5 feet below the original bottom, the water depth of 7.0 feet at the location of the center-cut boring indicates a refilling rate of 5.0 feet or 67% within 8 to 10 hours after shell dredging.

In addition to the above samples, representatives of the shell dredging industry have provided the Corps of Engineers with cross-section data of dredge cuts made in the project area from 1975 to 1984. These

data show an area prior to dredging (including the location of shell), bottom of the dredge cut, and the bottom of the area some time after dredging. These cross-sections are shown on Figures C-10 to C-13. Summaries of these surveys are shown on Table 6. The shell dredgers also surveyed some selected areas of Atchafalaya Bay at the request of the Corps of Engineers with a Corps representative present at the time of surveying. A summary of these surveys is shown on Table 7. The USACE also performs hydrographic surveys of the Atchafalaya Bay on a periodic basis, with transects approximately 2,600 feet apart. Using these surveys, polygons can be developed enclosing the areas of concentrated shell dredging. Although the level of detail of these surveys is not great enough to show details of actual cuts, some statistics can be derived from the surveys. These are shown on Table 8.

From these data, several conclusions can be made. In an area where riverine processes (river flow and sediment transport) dominate, as it appears in the area dredged in 1975, dredge cuts display characteristics similar to sediment traps. Cuts fill rapidly with material from the Atchafalaya Basin Floodway and become indiscernable from adjacent undredged areas. In areas where riverine processes compete with coastal processes (currents, tides, wind driven tides, hurricanes), the rate of fill can vary. Dredge cuts made in 1980-81 are located in an area with strong tidal influences. There is a distinct path of tidal exchange starting just west of North Point, traversing in a northeastern direction through the Atchafalaya Bay and into Four League Bay. This tidal influence appears to have caused a significantly lower rate of fill of dredge cuts in that area than to those to the west. In addition, distributary channels of the delta north of this area are apparently filling with sediment, reducing the amount of material available for deposition. This reduction of available material may have some contributory effect on the rate of fill in the area dredged in 1980-81. It may also have an effect on dredge cuts on the entire east side of the delta above the latitude of South Point.

Dredge cuts are not always the only holes and troughs made during the dredging operations. There are cases where a dredge must dredge a channel for access to the area to be dredged for shell. These channels are not as deep as the cuts and probably are maintained until dredging operations are moved to another part of the Project Area. After abandonment, these channels would also have to fill with sediment.

TABLE 6

CHARACTERISTICS OF DREDGE CUTS

	VOLUME OF SHELL REMOVED CUBIC YARDS	THICKNESS OF SHELL LAYER (AVG IN FT)	AVG CUT WIDTH FEET	MAX BOTTOM DEPTH BEFORE DREDGING, FT.	MAX DEPTH DREDGE CUT (FT)	MAX BOTTOM DEPTH, 1984 (FT)	MAX BOTTOM DEPTH, 1986 (FT)
1975	4,806,506	6	400	7.5	20	N/A	0*
1980	3,560,458	8	850	5	25	12	6
1982	2,446,141	10	850	7.5	30	13.5	10
1984	3,198,864	8	800	5	25		7

Table 7

Characteristics of Dredge Cuts

1980-1981 Dredge Area

	Maximum Bottom Elevation from 1981 USACE Survey (Ft. NGVD.)	Maximum Bottom Elevation from 1986 Survey (Ft. NGVD. approx)
AREA 1	-14	-12
AREA 2	-15	-9
AREA 3	-10	-6

Table 8

STATISTICS OF ELEVATIONS

IN AREAS OF DREDGING

	1976 USACE SURVEY				1977 USACE SURVEY				1981 USACE SURVEY			
	AVG	MODE	MAX	MIN	AVG	MODE	MAX	MIN	AVG	MODE	MAX	MIN
1977 DREDGE AREA	-8.2	-8	-9	-4	-8.2	-8	-9	-5	-7.8	-8	-9	-5
1978 DREDGE AREA	-6.5	-6	-12	-5	-7.2	-7	-15	-5	-7	-7	-9	-6
1980 DREDGE AREA	-4.5	-5	-7	-3	-4.1	-4	-6	-2	-4.9	-3	-15	-2
1981 DREDGE AREA	-6.4	-7	-9	-4	-6	-6	-8	-3	-6.6	6	-14	-4

Atchafalaya Delta

Before 1950, mainstem lakes within the Atchafalaya Basin were receiving most of the sediments transported by the Atchafalaya Bay Floodway System. Cratsley (1975) reported that insignificant sedimentation occurred in Atchafalaya Bay between 1858 and 1952. Sediments that escaped the mainstem lakes bypassed the Atchafalaya Bay and were deposited on the inner shelf. Shlemon (1975) states that approximately 6 feet of clay was deposited seaward of Point au Fer reef between 1889 and 1935 and another 3 feet by 1951. Two explanations have been offered for this apparent bypassing of the Atchafalaya Bay. Morgan, et al. (1953) indicated that suspended clays transported down the Atchafalaya River flocculated upon reaching the saline waters seaward of the Atchafalaya Bay, thus forming a blanket of prodelta clays on the shelf alone. In addition to flocculation, Thompson (1955) used the concept of equilibrium depth, a depth maintained by nonhurricane wave action, as a means of explaining the lack of permanent sedimentation in the bay.

By the mid 1900's the mainstem lakes had reached enough of a sediment filled state that prodelta clays began accumulating in Atchafalaya Bay. The decade 1952-1962 marks the beginning of a subaqueous delta at the mouth of the lower Atchafalaya River. By 1962, upper prodelta sediments covered a large area of the Atchafalaya Bay (Van Heerden, 1983). The first introduction of silts and sands to the bay occurred between 1962 and 1972 and the subaqueous delta continued to develop. The thickest accumulation of sediment was west of the Lower Atchafalaya River and Wax Lake OUtlet, reflecting partly the position of submarine spoil banks. By 1972, the submarine delta front had advanced to the Point au Fer Shell Reef (Van Heerden, 1980). Also prior to 1972 the first series of scour channels formed just inside the Point au Fer Shell Reef (Wells et al., 1984). The flood of 1973 produced the first natural subaerial delta on both the east and west sides of the Lower Atchafalaya River Navigation Channel. Rapid growth over the next three years resulted in approximately 32.5 km2 of new land in the Lower Atchafalaya River delta

(Rouse et al., 1978) and the emergence of 3.8 km2 of new land in the Wax Lake Outlet delta (Van Heerden, 1980).

Between 1976 and 1979, the deltas experienced a slight loss of subaerial land as a result of resuspension and redistribution of sediments from land to water, loss of elevation due to compaction, consolidation of sediments, and other forms of subsidence, and a reduction of sediment supply. This loss is a part of the delta's subaerial growth and decay cycle, a repeatable cycle on a geologic time scale. The deltas experienced subaerial growth in 1979 followed again by some decay. There was erosion in the middle of the bay and close to the reef as the bay apparently was adjusting hydraulically to the severe changes in bathymetry.

In 1980, subaerial land was determined to be 8 square miles above the 1969 0 feet NGVD contour. Between 1980 and present, Wax Lake Outlet has continued to experience subaerial growth. The Lower Atchafalaya delta has shown subaerial growth, but also some decay.

The one major source of sediment for delta development is sediment transported by the Atchafalaya Basin Floodway system. The average daily measured suspended sediment load at Simmesport for the period 1951 through 1981 is 283,000 tons per day. The sediment load has been declining throughout this period. However, a better representation of the load would be the average load for the last 10 years of available record (1973-1982), which is 260,000 tons per day. Approximately 19 percent of the sediment is sand and 81 percent silt and clay.

There are several sources of significant energy for creating and reworking delta deposits in the Atchafalaya Bay and vicinity. The primary source of energy relative to delta evolution is the river discharge. The mean flow at Simmesport for the period 1930-1984 is 187,000 cubic feet per second (cfs). The maximum average monthly discharge for that period is 322,000 cfs, occurring in April, and the minimum monthly average of 81,000 cfs in September. The flow at the

lower end of the basin is split between Wax Lake Outlet and the Lower Atchafalaya River. The location of Wax Lake Outlet relative to Morgan City gives it a distinct gradient advantage to Atchafalaya Bay.

A second source of energy is tides. Tides in the region of the Atchafalaya Bay alternate between diurnal and mixed, with principal diurnal tides being dominant over the principal semi-diurnal constituents. Tides exhibit mixed-tide behavior during neap tide periods and diurnal tide behavior during spring tide periods. Tidal energy is not of great significance relative to tidal energies on the Atlantic or Pacific coast; however, circulation patterns induced in the bay by the tides may be important, since there is a predominant net transport of water to the west over the tidal cycle (Van Beek et al., 1977). The mean diurnal tidal range of 1.5 feet generates a tidal prism amounting to 25 percent of the volume of water within the bay. For a diurnal spring tide range of 2.7 feet, the tidal prism is 40 percent of bay volume. Although possibly less significant as energy for suspending sediments, tidal currents play an important role in transporting and flushing sediment suspended by other mechanisms.

A third source of energy is wind. The long east-west fetch length of the Atchafalaya Bay results in wind generated waves of 1 to 2 feet fairly frequently (Cratsley 1975). These waves provide the primary mechanism for resuspension of deltaic sediments on delta lobes and are thought to be responsible for reworking of the delta during periods of prolonged low riverflow. The remaining barrier shell reef on the gulf side of the bay provides some protection from gulf wave energy, but some energy is transmitted across the reef. Wave dampening effects of Point Au Fer Reef have all but disappeared over the last 20 years. Approximately 15,000 feet of reef deposit remain intermittently exposed above natural bottom, offering some protection for the eastern portion of the Atchafalaya Bay. Observations of waves from offshore oil platforms indicate that, 95 percent of the time, waves are less than 4 feet (Cratsley 1975). Waves as high as 10 feet have been observed during hurricanes. These high waves, coincident with surges in the water levels in the bay, provide a great deal of energy to the bay.

Winter storm fronts that pass through the area can have a significant impact on water surface elevations in the bay (Van Heerden and Roberts, 1980). Typically, the fronts pass from a northeasterly direction as the front passes. Southwesterly winds preceding the front cause a setup of water surface elevations in the bay; then as the front passes, the northeasterly winds, in addition to the gradient in water surface during setup, push the water out of the bay and cause a setdown of water level. This frequently exposes much of the delta front to wave action, and tides 2 feet below normal are not uncommon after such events.

The USACE is currently involved in a study of the Atchafalaya Bay to determine long and short term evolution of the delta and its effects on flood control, navigation, and other hydrological factors. Preliminary results from this investigation are as follows:

The deltas will expand to about 19 square miles of subaerial land, about 110 square miles of depths less than 3 feet, and about 6 billion cu ft of sediment by 1990. By 2030, the delta will expand to about 60 miles of subaerial land, 377 square miles of depths less than 3 ft, and 21 billion cu ft of accumulated sediment. This accumulated sediment in the delta is approximately 15 percent of the sediment load available as measured at Simmesport. Essentially continuous delta growth is expected through 2020 with minor interruptions. The delta may experience brief periods of subaerial land loss prior to subsequent episodes of land building. The longer term trend will be continued land growth and roughly constant growth of accumulated sediment volume.

As part of a research program initiated in 1977 by the Center for Wetland Resources, Louisiana State University, a coring program, combined with historical and recent bathymetric data as well as published reports on subsidence, was used to construct stratigraphy of the delta (Van Heerden, 1983). Delta morphology and development was inferred for the historical development of the delta. Core lines are shown in Figure C-14. Figures C-15 and C-16 show the stratigraphy of the delta for two core lines. Note the presence of shell dredge material in one of the core lines.

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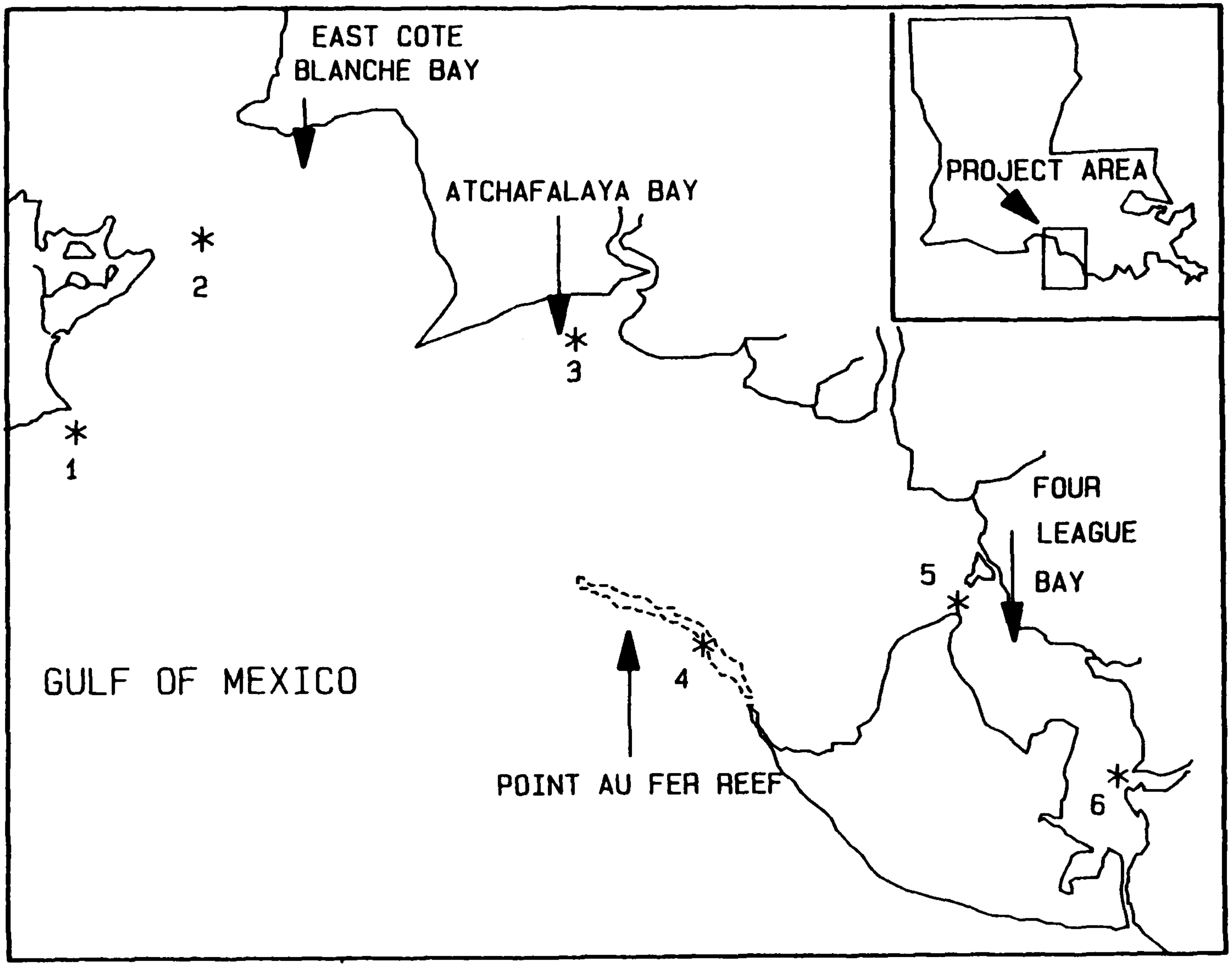

Figure C-1. Station Map for Water Quality.

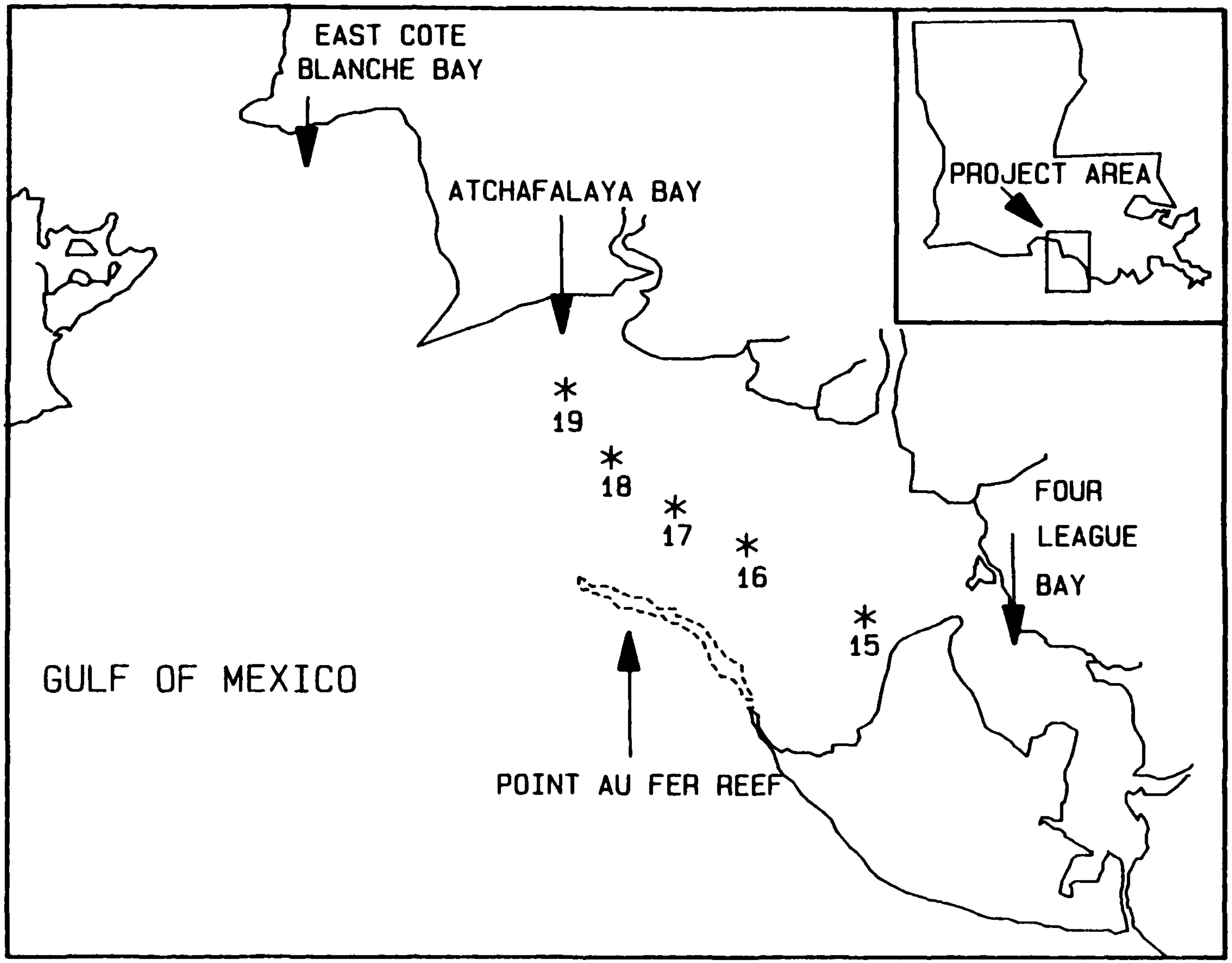

Figure C-2. Water and Sediment Quality Sampling Stations.

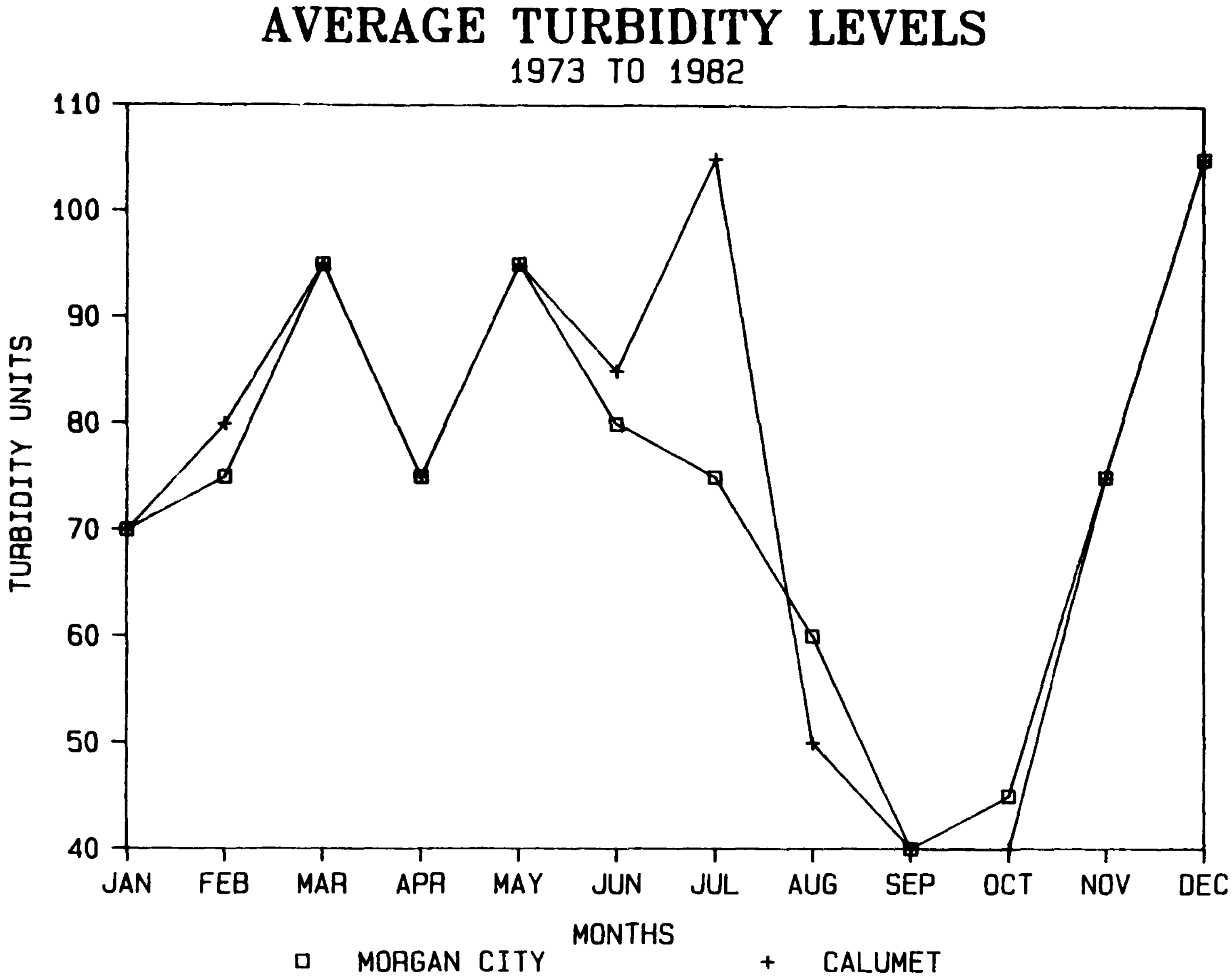

Figure C-3. Average Turbidity readings from 2 stations

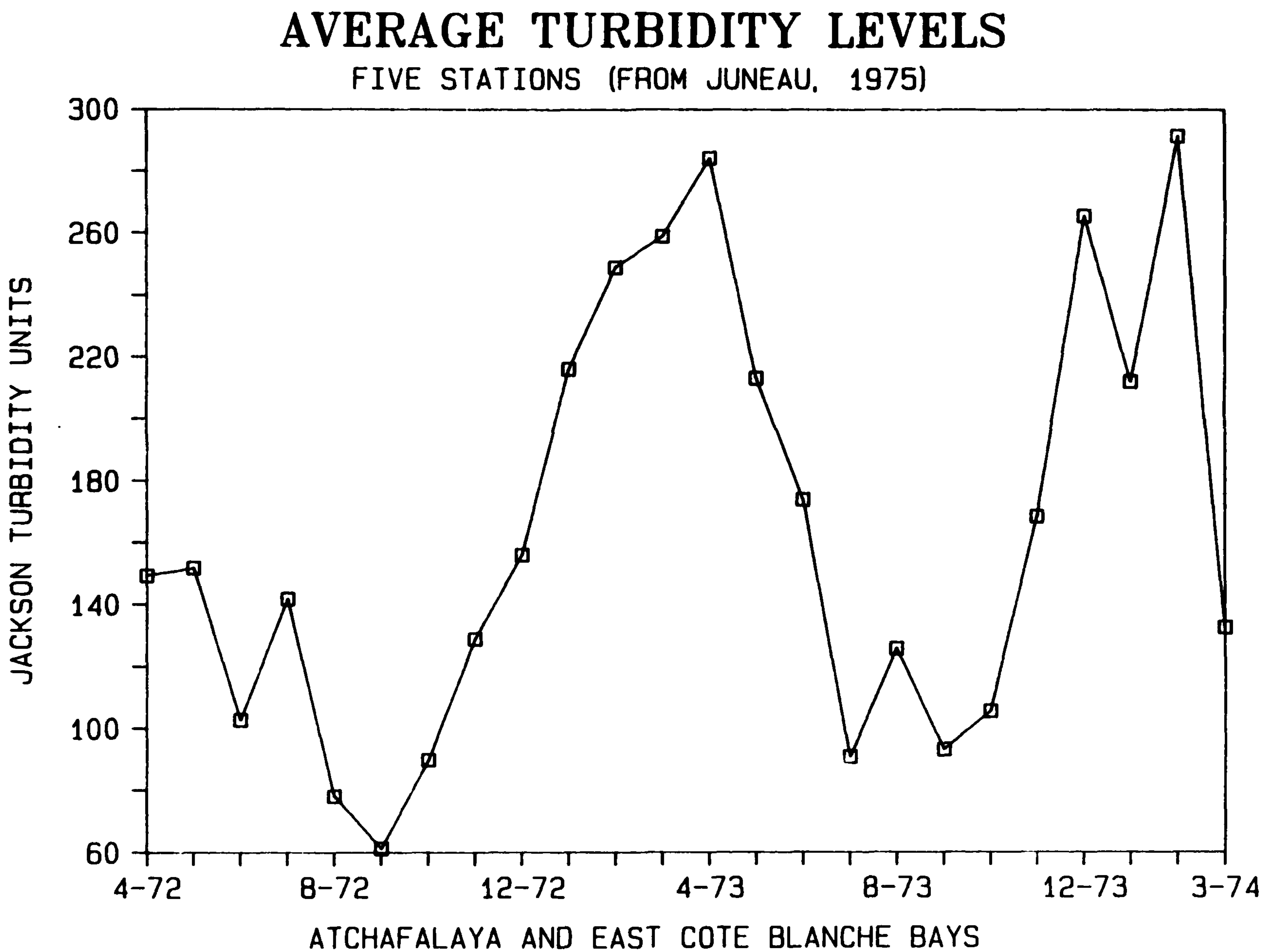

Figure C-4. Average Turbidity Readings from 5 stations in the project area.

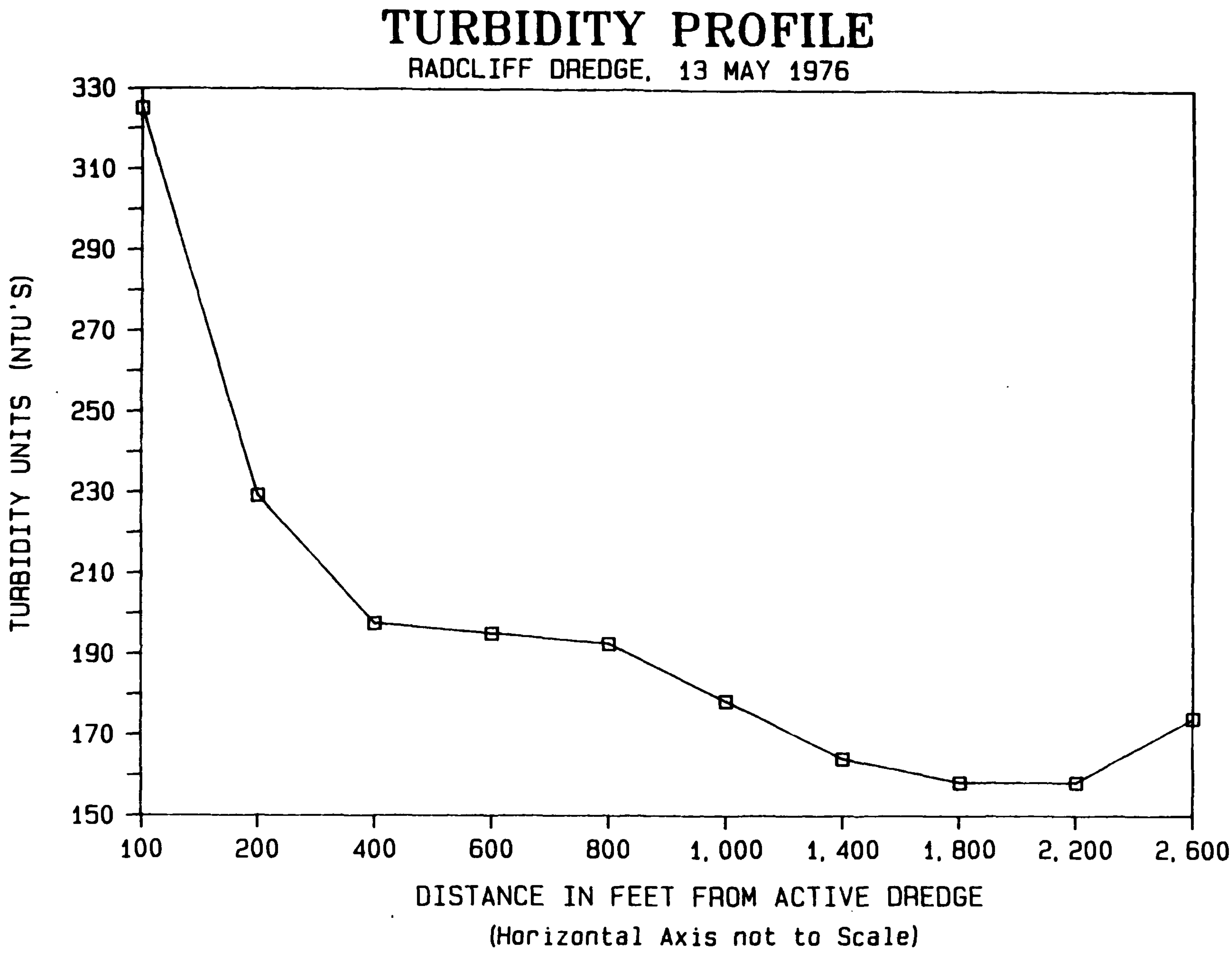

Figure C-5. Average Turbidity Values in Relation to Distance from Dredge (13 May, 1976)

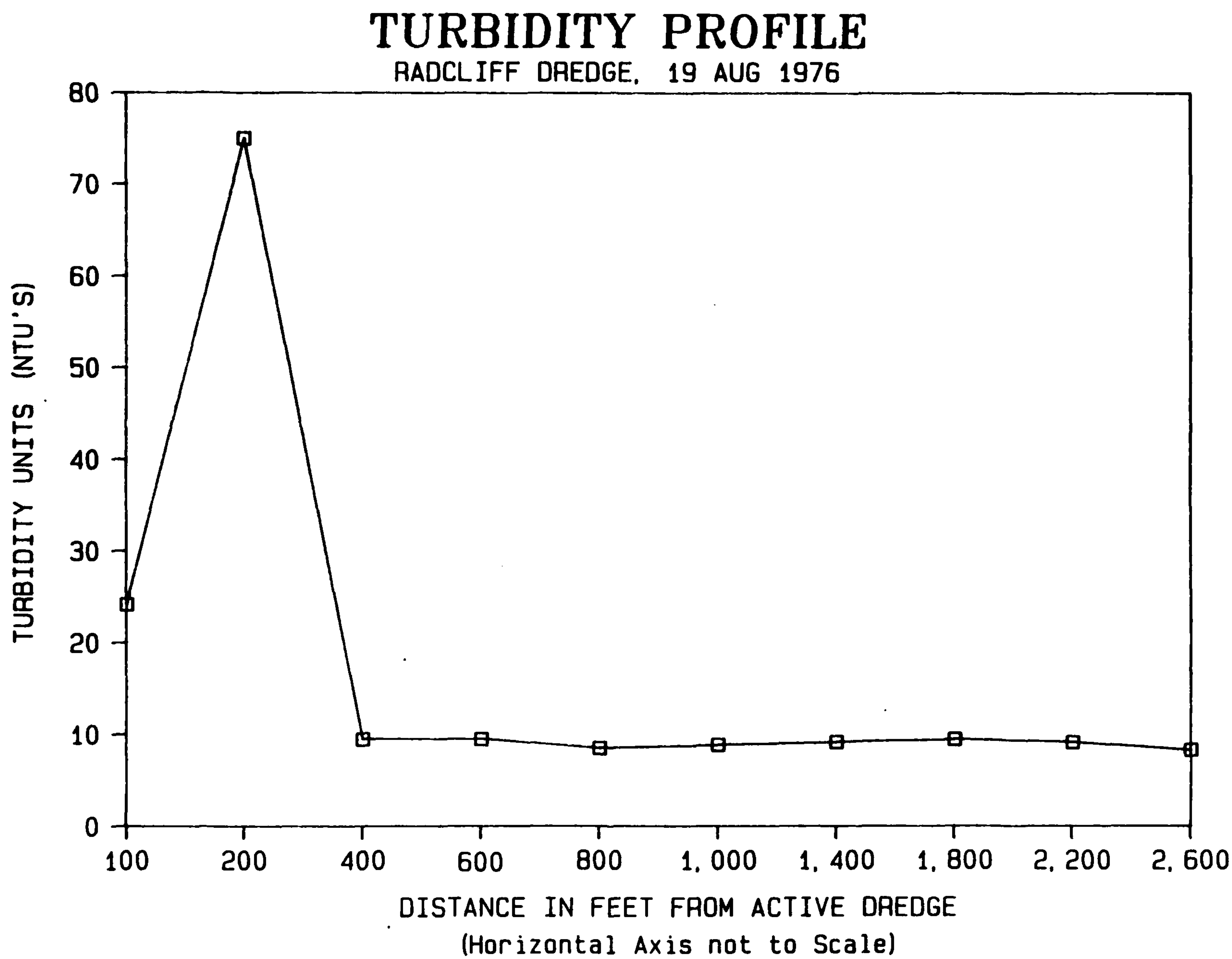

Figure C-6. Average Turbidity Values in Relation to Distance from Dredge (19 Aug. 1976).

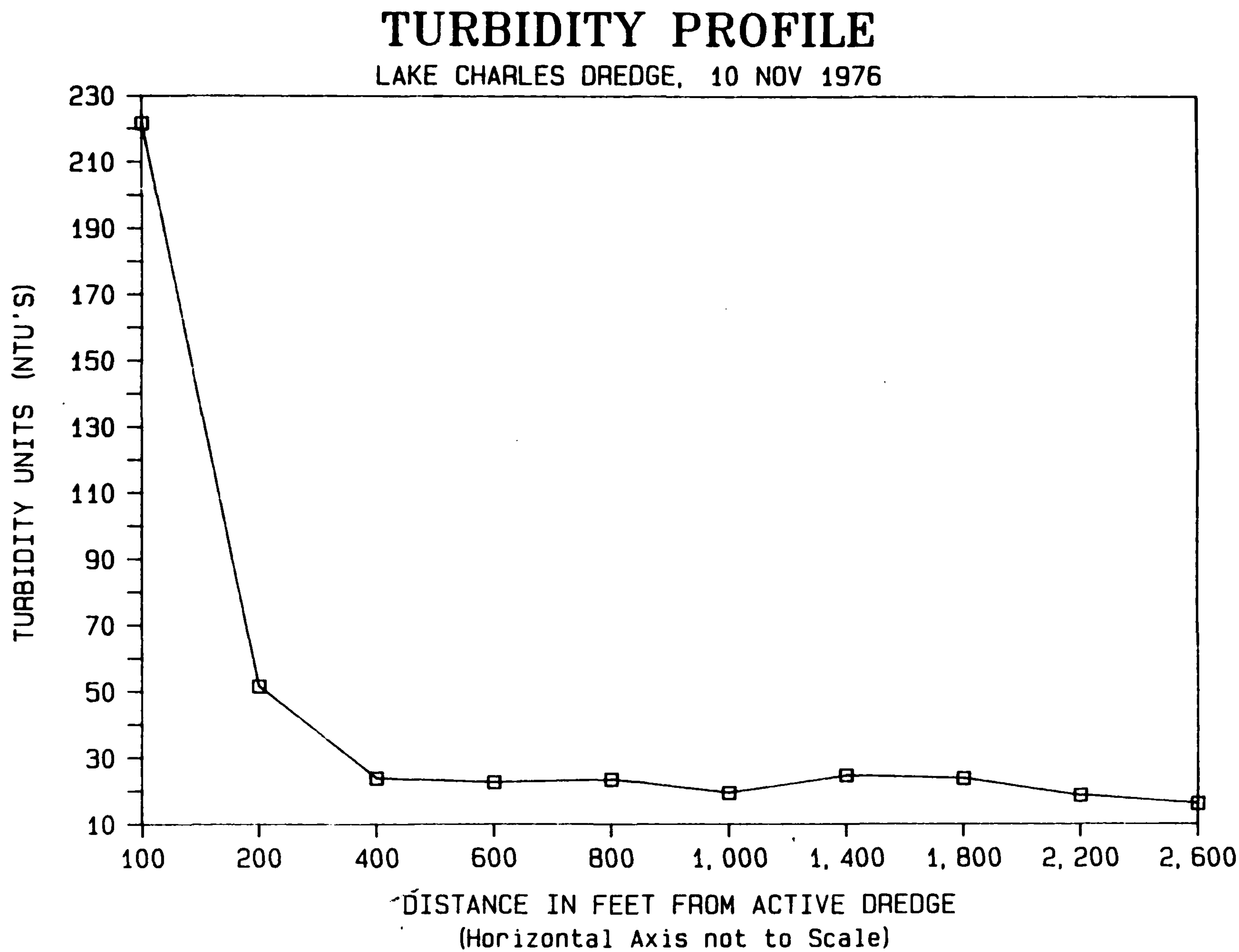

Figure C-7. Average Turbidity Values.

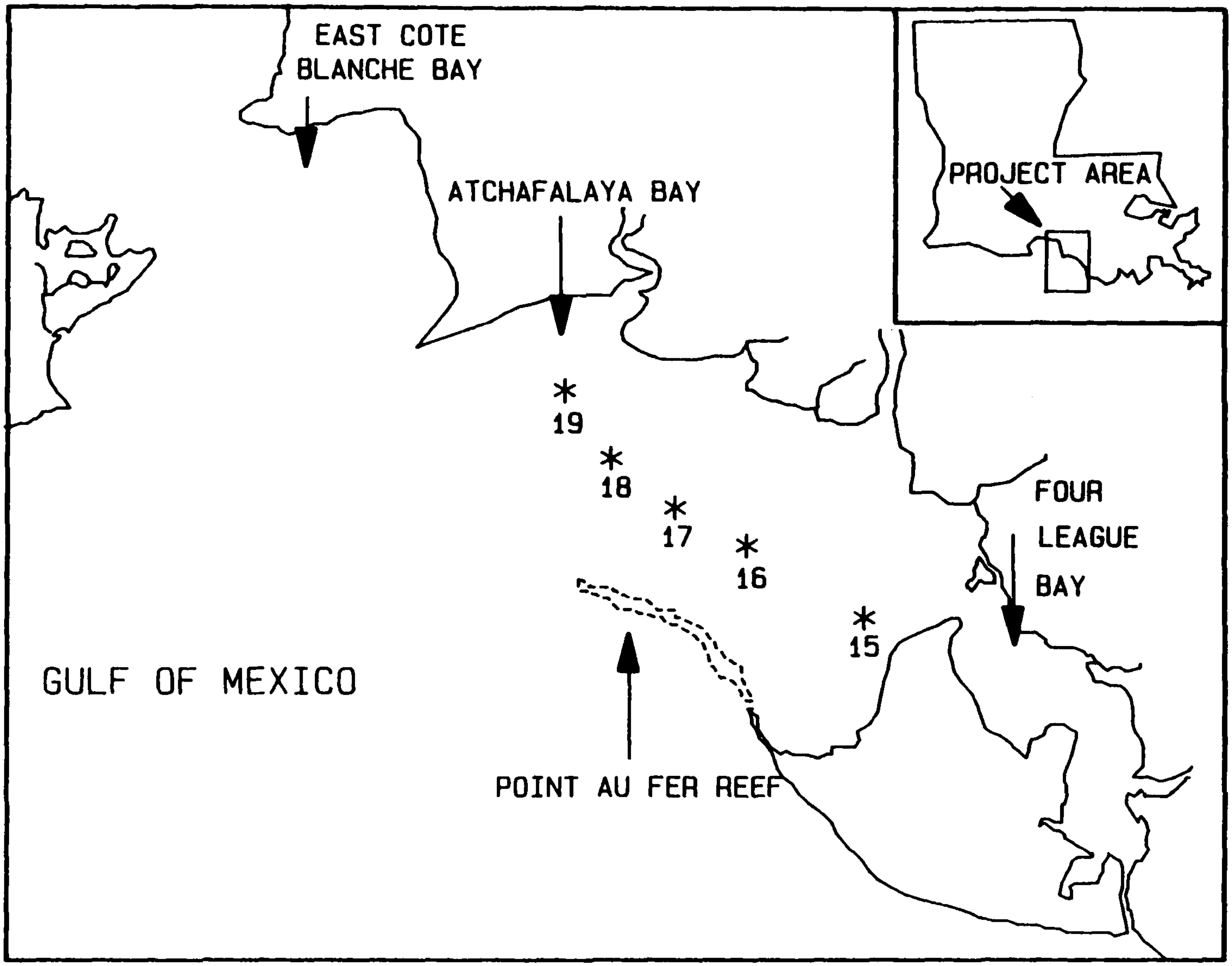

Figure C-8. Water and Sediment Quality Sampling Stations.

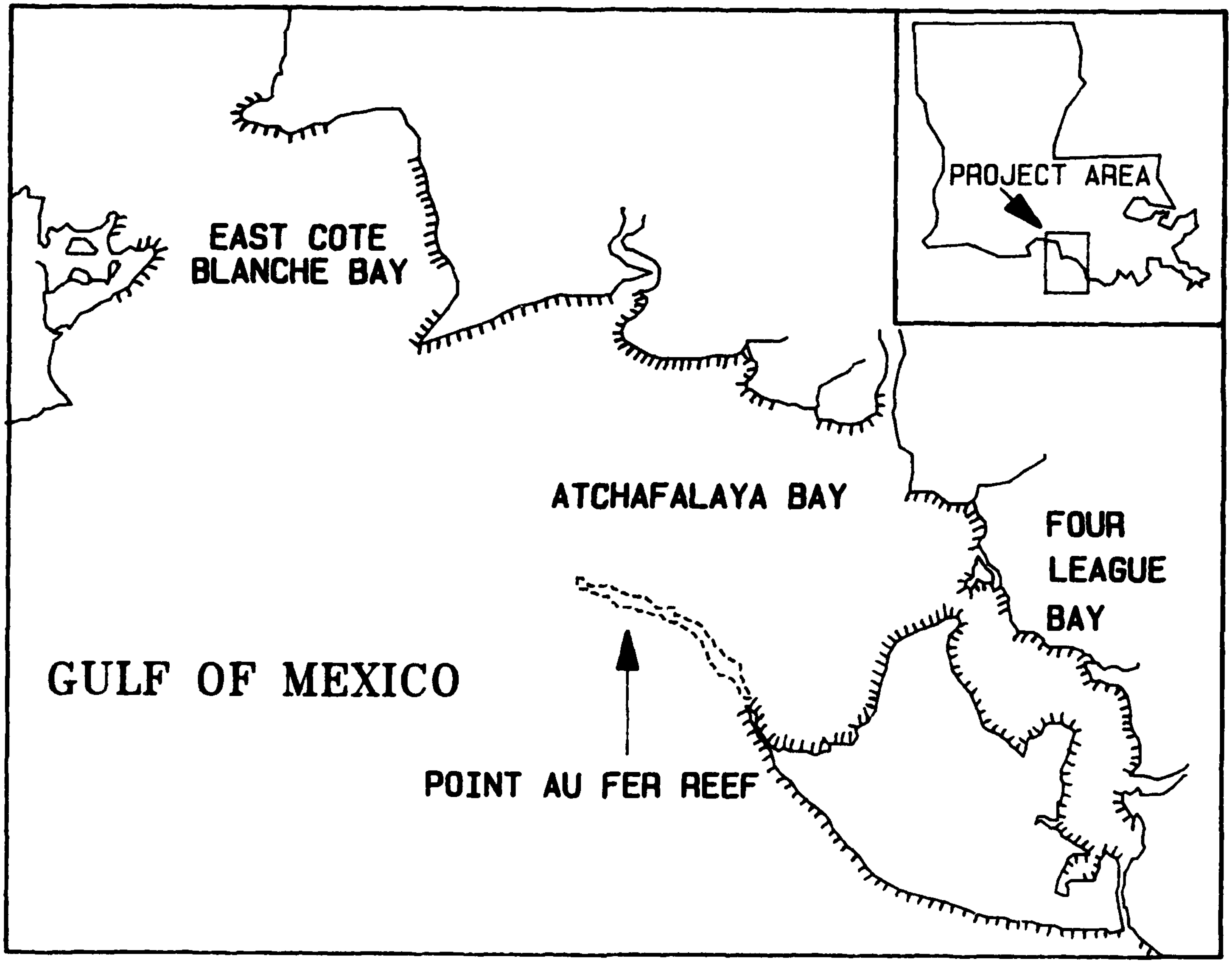

Figure C-9. Areas of Coastal Shoreline Erosion, 1930's to 1982.

DREDGE CUT, 1975
ATCHAFALAYA BAY NEAR WAX LAKE OUTLET

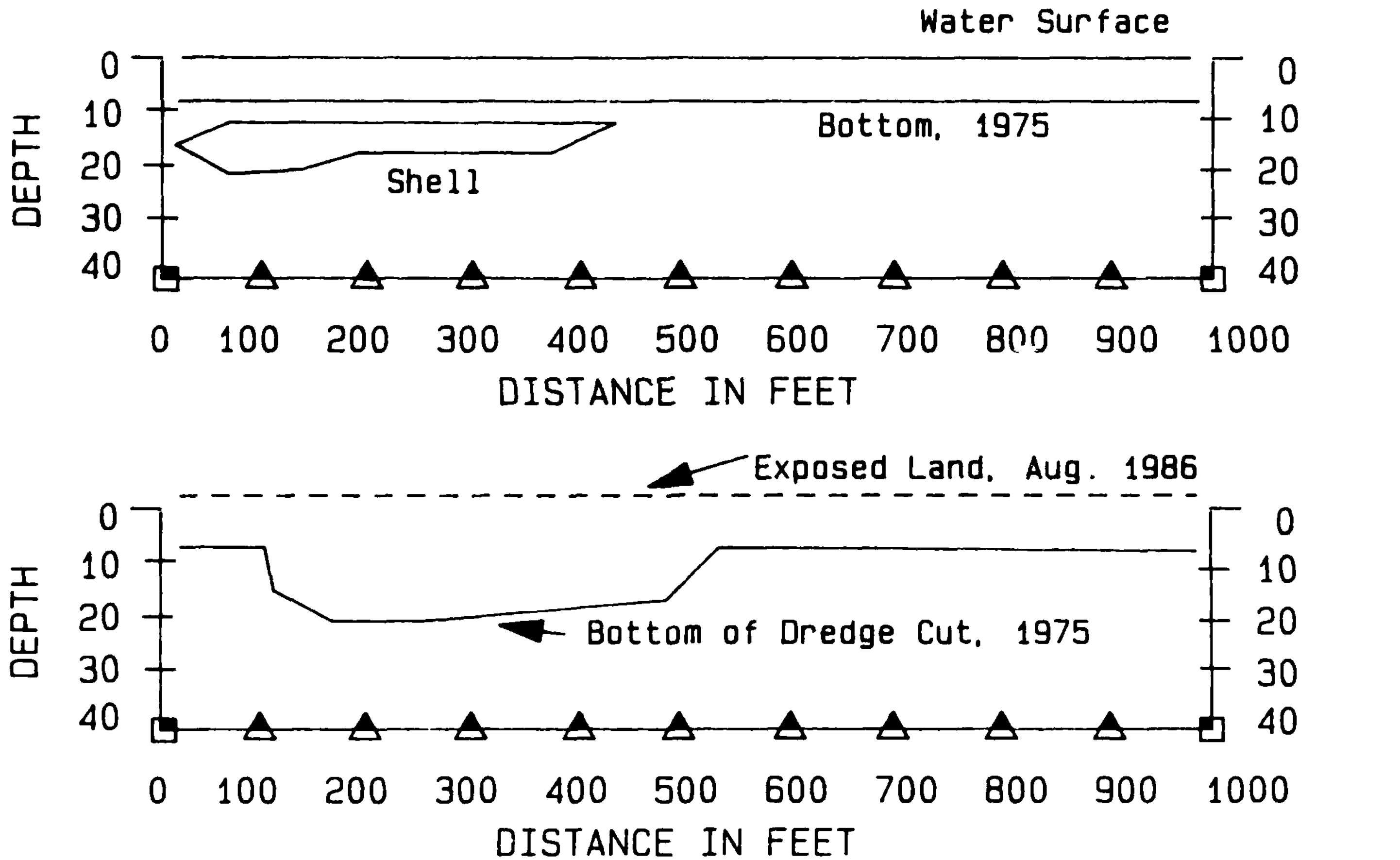

Figure C-10

DREDGE CUT, 1980
ATCHAFALAYA BAY, BETWEEN SOUTH POINT AND NAVIGATION CHANNEL

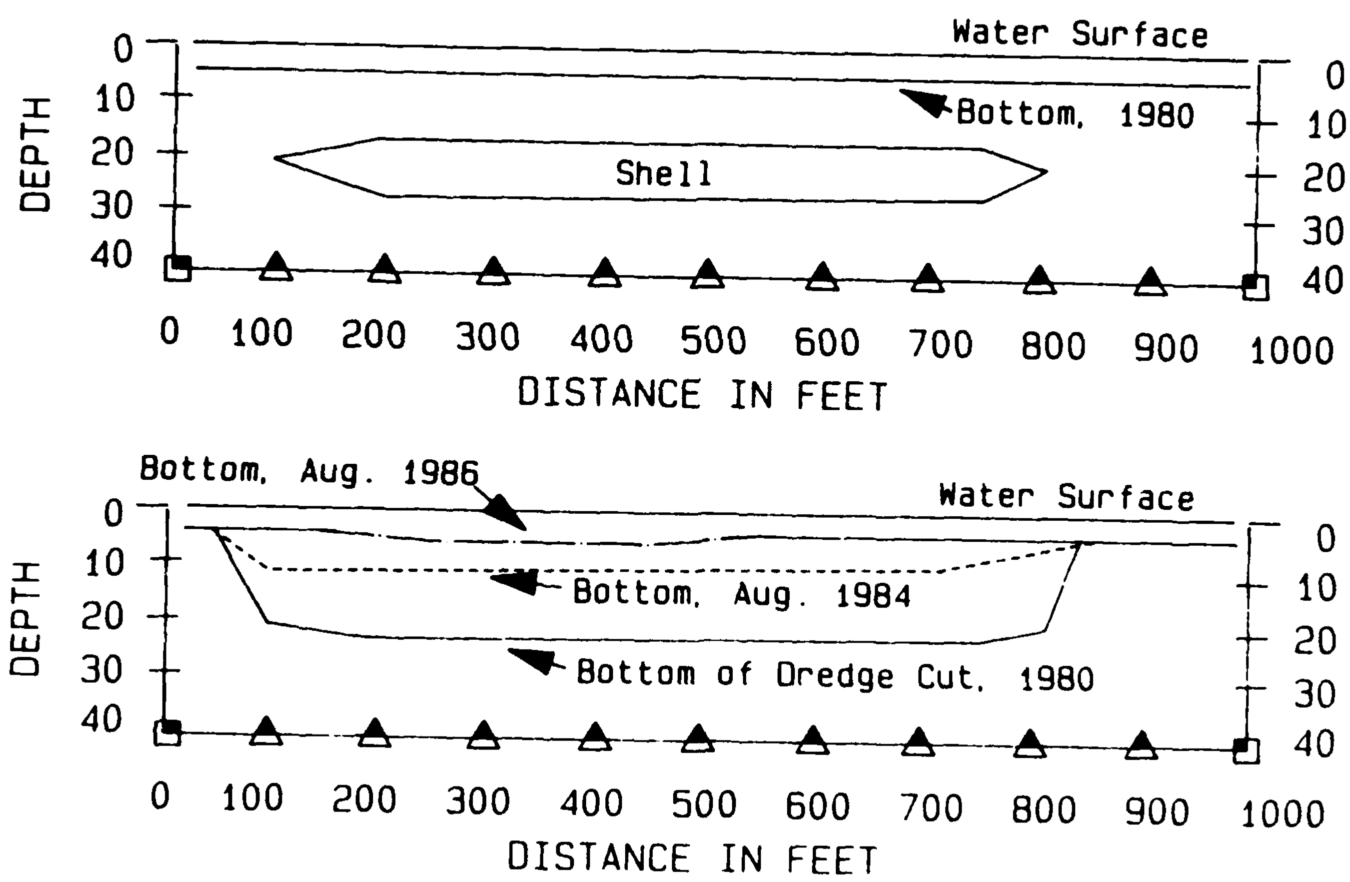

Figure C-11

DREDGE CUT, 1982
MOUTH OF FOUR LEAGUE BAY

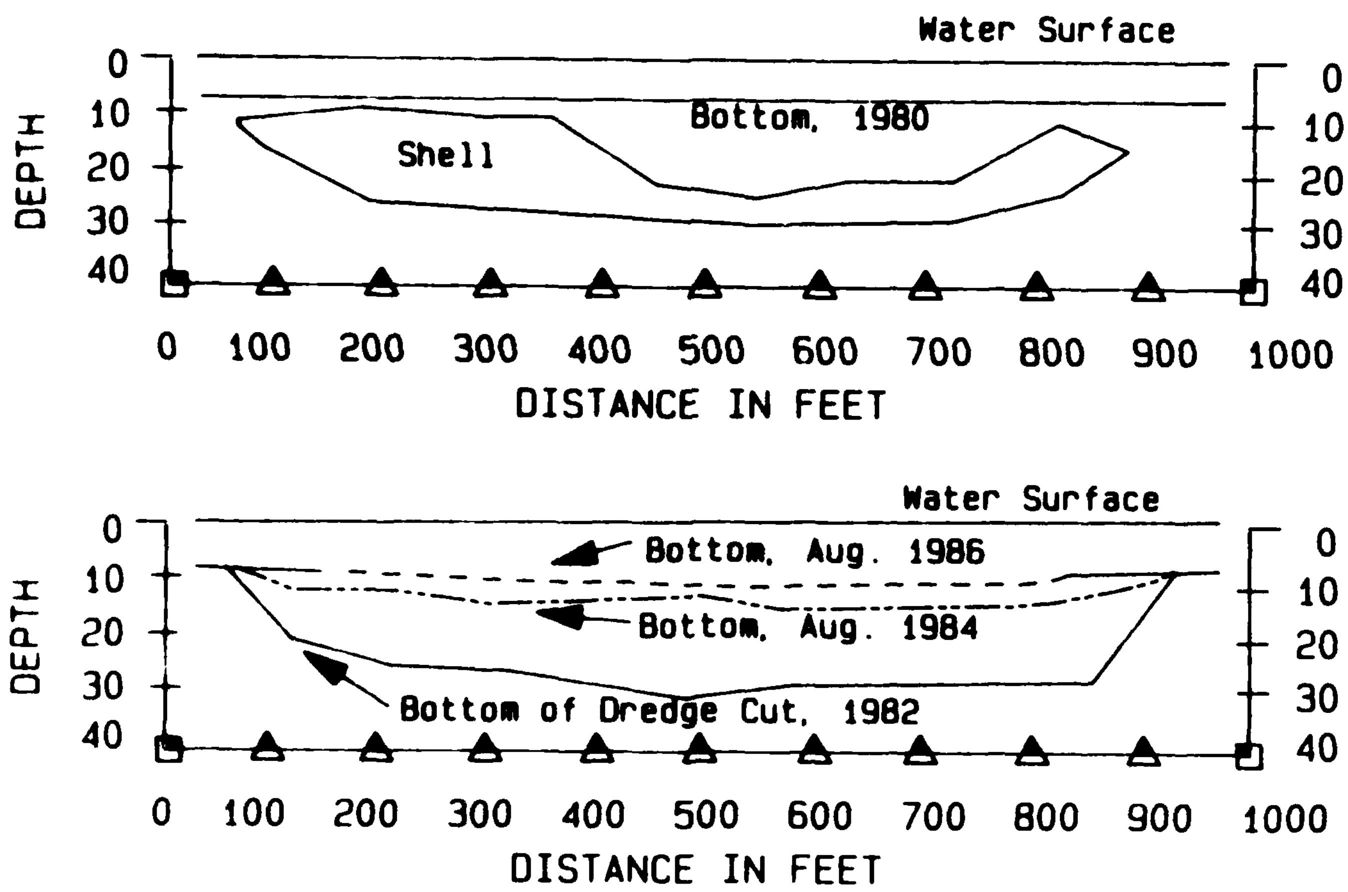

Figure C-12

DREDGE CUT, 1984
FOUR LEAGUE BAY

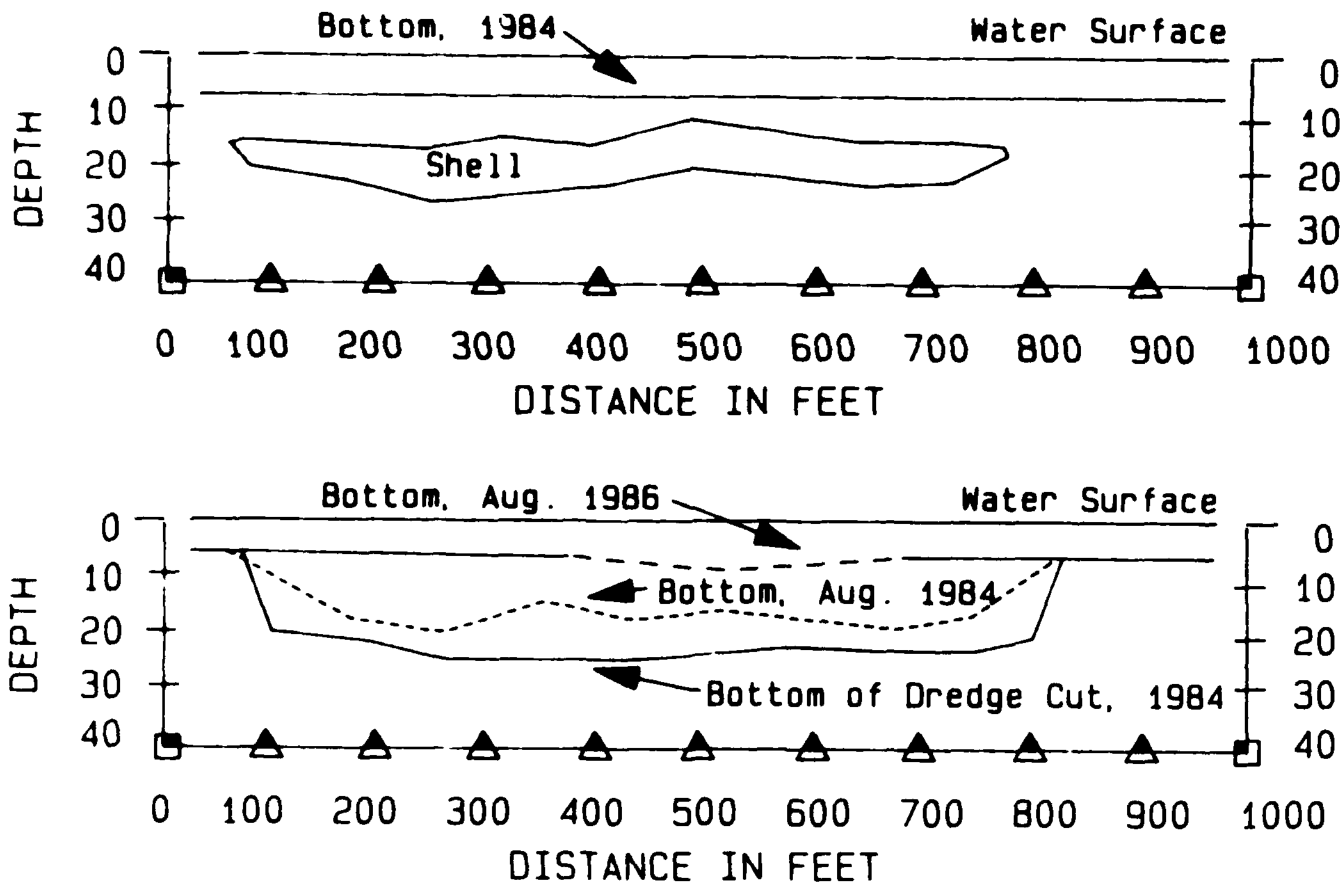

Figure C-13

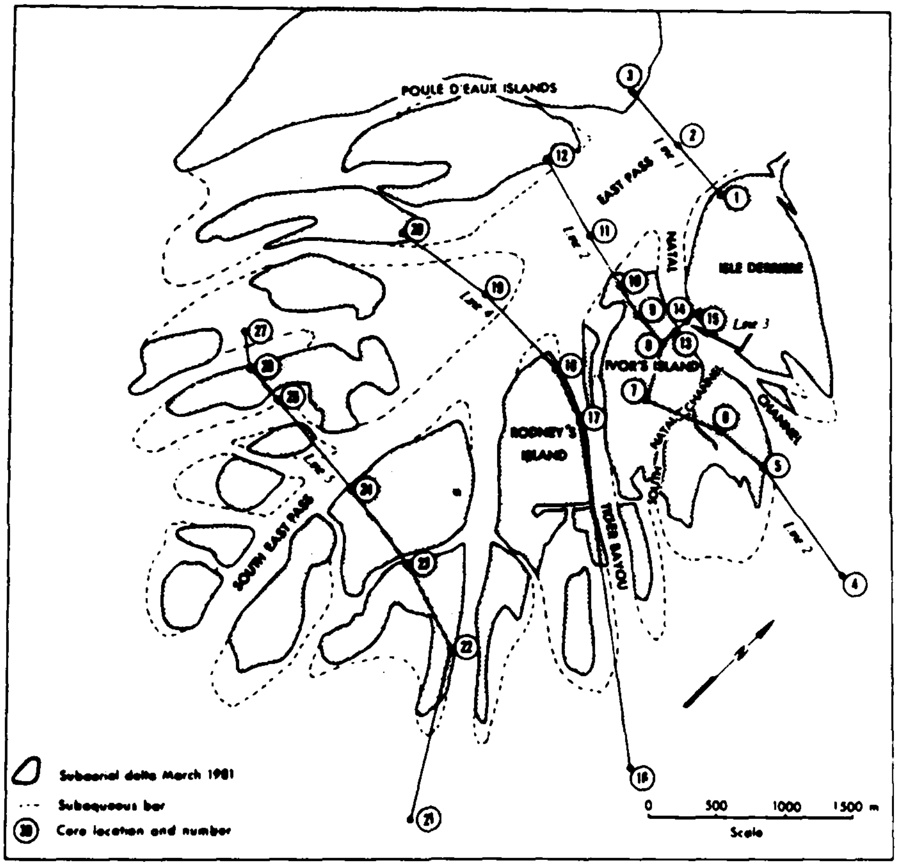

Figure C-14. Lines of Deep Vibracores in the Eastern Atchafalaya Delta.

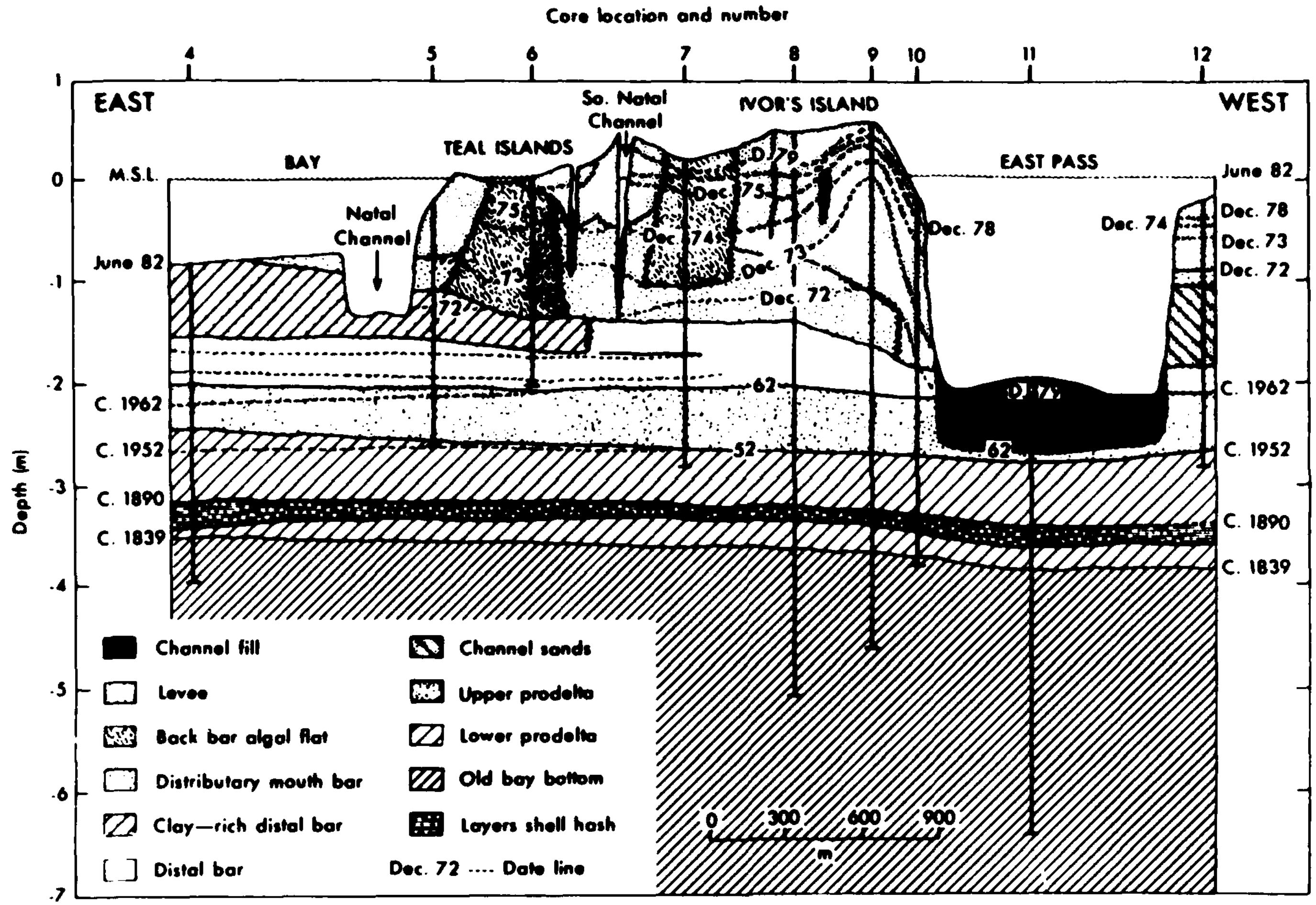

Figure C-15. Core Line 2. See Figure C-14 for Location.

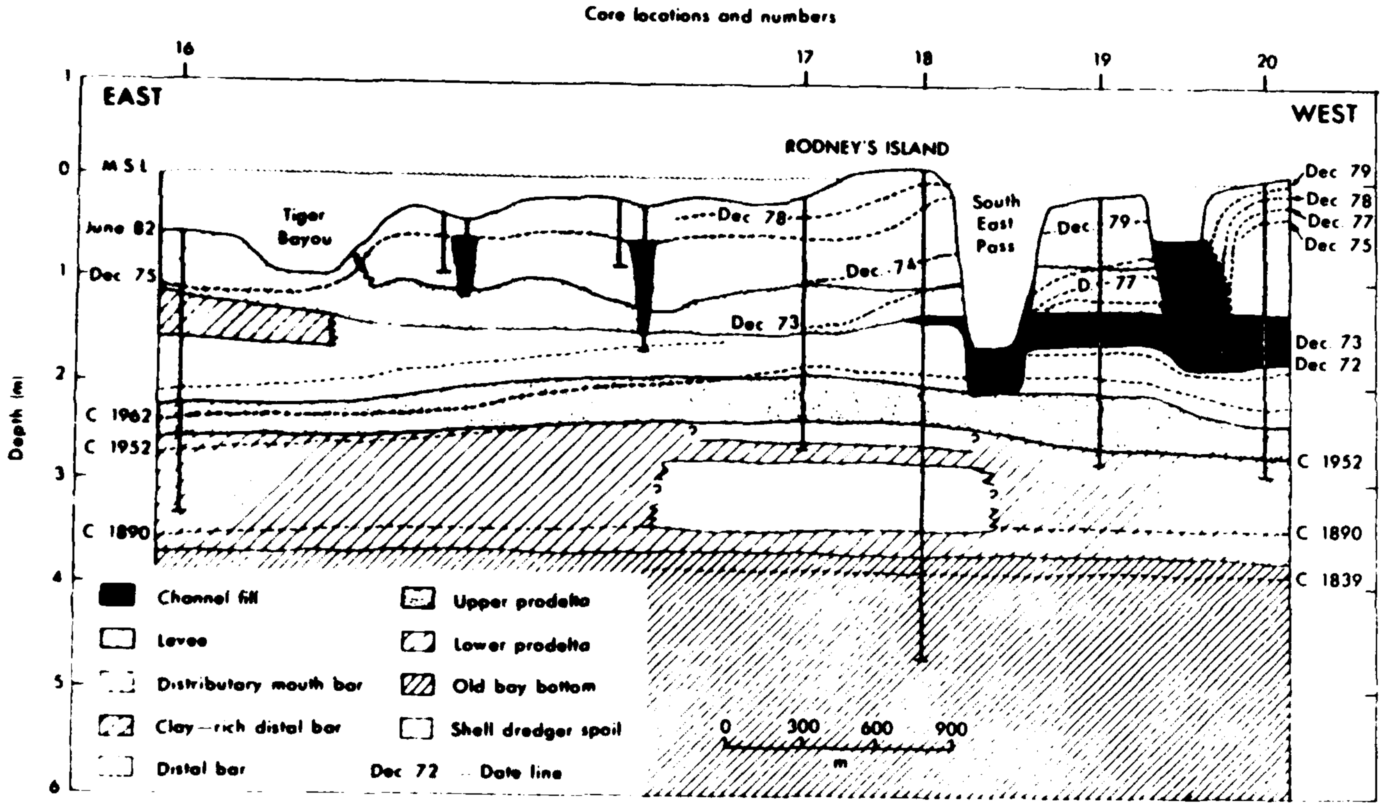

Figure C-16. Core Line 4. See Figure C-14 for Location.

APPENDIX D

BIOLOGICAL ENVIRONMENT

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APPENDIX D

BIOLOGICAL ENVIRONMENT

Introduction

The purpose of this appendix is to provide background information on the environment which may be affected by the proposed action. Much of the information is detailed and, because of its length, can not be incorporated into the body of the EIS. This technical review of the environment and the dominant species is provided to allow the reviewer to form an opinion based on the most current information available.

Phytoplankton

Current knowledge of the phytoplankton and primary production within the estuarine systems of the project area is derived primarily from the works of Theriot (1976) and Randall (1986). The work of the first author dealt with the taxonomic composition of the phytoplankton of the coastal region, while the latter author addressed aspects of primary productivity in Four League Bay.

Theriot (1976) reported 65 genera of phytoplankton from 177 samples collected from July 1974, through November 1975, in stations distributed around the Four League, Atchafalaya, and East Cote Blanche Bays (Figure D-1). Theriot has shown diatoms contributed 49% of the overall cell count, with centric diatoms collected in 99% of the samples. The abundance of this group of diatoms was such that it constituted 76% of the total diatom catch. Theriot stated, "in order of decreasing cell count abundance, regardless of frequency of occurrence, the ten most abundant taxa or groups in decreasing order were centric diatoms, Scenedesmus, Anabaena, green coccoid forms, Anacystis, Crucigenia, pennate diatoms (except Diploneis), Nitzschia, Diploneis and Agmenellum." Dinoflagellates, Xanthophyceae, and Chrysophyceae were shown to be low in overall abundance and only sporadically collected.

Phytoplankton abundance within the coastal area was shown by Theriot to have highest seasonal peaks in August, with lesser peaks in October-November and May-June. These peaks were coincident with low river discharge and often dominated by different groups of phytoplankters. The author suggested these peaks in abundance were attributable to the lowered turbidity and that wind and wave activities exhibited major influences on the standing crop. Supporting this conclusion, the author examined light-extinction at two stations during the course of the study. The compensation level was reported to be about 0.75 meters at one station, and 3 meters at the second station. This latter site was much more strongly influenced by high-salinity gulf waters at the time of the sample. This situation of less turbid waters is most obvious only at

times of low river discharge, when oceanic waters exert maximum influence on bay waters. However, this condition was found to be atypical and during the course of the study Secchi disc readings averaged only 30 centimeters (12 inches).

Theriot has shown that the naturally turbid waters of the Atchafalaya River and Wax Lake Outlet are detrimental to the phytoplankters most often encountered in the region. His results indicate much higher productivity and standing crop in regions minimally affected by the freshwater inflow (e.g., the extreme eastern portions of Four League Bay). The actions of wind and waves, "by dispersing phytoplankton and suspending sediments, reduced primary production and consequently, the usual estimates of phytoplankton standing crop in the bay were low, especially on the west side of Atchafalaya and in East Cote Blanche Bay.

Randall (1986) established two stations in Four League Bay, one in the northern and one in the southern extremity. These sites were used as locations for the approximation of primary productivity in the northern and southern portions of the bay. Randall's work has shown, as has that of the above author, the dominating influence of the river on the natural functions of the coastal estuaries. His discussion summarized some of the effects of the river by stating (p. 40) that two measures of production "were negatively correlated with river flow at both sites in the bay as a whole. Light limitation due to the extreme turbidity of the water introduced by the river was apparently largely responsible for these trends. In general, light penetration increased with distance from the river due to settling of particles and mixing with clearer Gulf water, and turbidity decreased as riverflow decreased."

Randall has shown that primary productivity estimates within Four League Bay are high when compared to ranges established by previous authors for naturally turbid estuaries. This relatively high productivity may be a function of the shallowness of the bay. High freshwater inflow provides a source of nutrients for this high productivity, but at the same time has a limiting effect by the discharge

of highly turbid waters. This limiting factor is evident when comparing annual net production at the upper bay and the lower bay stations. The upper bay station was shown to have an annual net production of 382.5 g of oxygen per square meter, only 37% of the 1,015.7 g of oxygen per square meter produced at the lower bay station. This discrepancy indicates highest productivity at the intermediate salinities most often encountered in the lower portions of Four League Bay. When higher salinity waters were pushed into the lower portions of the bay, productivity often decreased, probably a function of lower nitrogen levels in the nutrient-poor gulf waters.

Turbidity in the aquatic environment is a natural fact in the shallow estuaries of coastal Louisiana, and has a variety of effects on resident organisms. A comprehensive synthesis of published reports dealing with turbidity impacts is that of Stern and Stickle (1978). Those authors attempted to put into perspective the complexities of the problem by stating:

> The responses of aquatic organisms to turbidity and suspended material are frequently difficult to determine because they may be due to a wide variety of causes, including the following: concentration of suspended solids or the number of particles in suspension, their densities, size distribution, shape, mineralogy, sorptive properties, or presence of organic matter and its form; inherent physical, chemical, and biological characteristics of each site; and antagonistic and synergistic effects."

The review by Stern and Stickle (1978) highlighted many of the most important ways in which turbidity may affect the primary productivity of a region. The authors summarized the work of many published reports and made the following conclusions. Turbidity may decrease light penetration and inhibit photosynthesis, depress dissolved oxygen values, alter water

temperatures, increase settling rates, or stimulate photosynthesis by resuspenion of nutrients.

Numerous studies have investigated the behavior of dredged material when discharged into water, both in the laboratory and in the field. Many of these reports have shown that most of the heavier particles settle out rapidly, with very little of the suspended material carried beyond 1,200 feet of the discharge. This distance is highly variable and dependent on a complex interaction of many environmental factors (e.g, winds, waves, tides, salinity, current patterns, etc.). Site specific work by GSRI (1977) on turbidity plumes in the project area has shown how dramatically these factors can affect turbidity levels. The characteristics of three separate plumes were investigated, yielding data to support the observations of the above-referenced authors. In two of the three cases, background turbidity levels (as measured by Jackson Turbidity Units, JTU's) were reached within 1,000 feet of an operating dredge. In the third instance, background levels were reached at 2,200 feet. This last instance illustrates well the combined effect of winds and currents. A generally westerly orientation of wind and current carried elevated turbidity levels 2,200 feet from the dredge, far beyond that normally seen. However, to the north and southeast, elevated turbidity levels did not extend [illegible]00 feet.

For the purpose of the analyses of impacts, a case beyond that normally encountered is used. The assumption is that elevated turbidity and suspended sediments are carried 1,500 feet away from the operating dredge in any direction, creating an area of about 3,000 feet in diameter impacted by increased turbidity generated from a single dredge. This area corresponds to approximately 162 acres impacted per dredge. Current permits allow for a maximum of two dredges to operate in 75% of the permitted areas. This increases to 325 acres the maximum area to be impacted by dredging operations. The 325 acres represents approximately 0.17% of the total water surfaces in the project areas. This figure, however, may be a little misleading. The bays, although interconnected, are not a single body of water and should also be considered separately.

The waters of Four League Bay cover approximately 20,500 acres, of which 325 acres would be impacted by increased turbidity levels, at any given time. This corresponds to 1.6% of the waterbody. Approximately 200,000 acres of water surface is located within the confines of Atchafalaya Bay. Two dredges operating in this region would impact approximately 0.2% of the waterbody at any one time. In East Cote Blanche Bay, permits currently allow a maximum of 4 dredges to operate. This would impact 650 acres, or 0.7% of the total 91,800 acres within the waterbody at any one time. It should be kept in mind that only two dredges have operated in the coast since 1983 and that a dramatic improvement in the economics of shell dredging would be required before the full complement of dredges (4) would operate in this latter area.

In summary, the impacts of shell dredging operations on the phytoplankton community, and thus primary productivity, are highly localized. This impact may take the form of lowering dissolved oxygen levels, decreasing light penetration, increasing settling rates of phytoplankters, and altering water temperatures in the immediate area. However, the resuspension of nutrients may also stimulate phytoplankton productivity. It should also be remembered that shell dredging operations are not the only source of suspended materials and that naturally high turbidities are commonplace in the Four League/Atchafalaya/ East Cote Blanche Bay system. These high turbidity levels are the result of high freshwater inflow from the rivers, wind-, wave- and storm-generated turbidities, natural erosion of the land, and resuspension of the fine sediments of the region. At any one time, the maximum permitted number of dredges would impact a small percentage of the waterbodies (from 0.2 to 1.6%). When placed in this perspective, the turbidity and associated impacts generated by the removal of a valuable resource are minor.

Fisheries

Fishery resources within the project area are those typical of the north central Gulf of Mexico with at least 108 species of finfish

recorded by several authors. The region is very productive in terms of fisheries resources and is projected to be of increasing importance with the development of the Atchafalaya Delta region (Thompson and Deegan, 1980). Although several works have been prepared which dealt with the fishery resources of the adjacent water bodies, few have dealt specifically with the East Cote Blanche/Atchafalaya/Four League Bay system.

Perhaps the most intensive work yet accomplished on the fishery resources of the project area is that of Bryan et al., (1976). Seventy-eight species of estuarine and freshwater fishes were reported from the marshes and adjacent waters of Four League, Atchafalaya, and East Cote Blanche Bays from August 1975 through April 1976 (Figure D-2). In order to efficiently sample the wide variety of stations from deep waters to shallow marsh, an assortment of sampling methods was used. The principle sampling device within the confines of the bays was a 10-foot seine and a half-meter plankton net. However, a 200-foot trammel net, beam trawls, 10-foot otter trawls, cast nets, a 30-foot bag seine, and an insect net were used infrequently in different habitats. Water quality parameters were measured and community resemblance was calculated from the data. This measure attempts to more closely reflect the structure of the community being examined than the more commonly employed species diversity indices.

The broad assortment of finfish gathered during the study reflects the variable environment of the coastal region of Louisiana. Bryan et al., (1976) reported 32% of the species gathered to have strong freshwater affinities. Fish considered to be strictly marine (Bailey, 1970) were encountered 27% of the time, while euryhaline species represented 41% of the total taxa collected. This community of fish is a reflection of a system with rapid shifts in the dominant physical parameters and strong seasonal influence. Community resemblance values have shown that stations within the bays are more similar to each other than were the marsh-pond stations. This result is not too surprising, as

ponds within the study area were generally more widespread and strongly influenced in different ways by the high fresh water input of the rivers.

Results of the study by Bryan et al., (1976) indicate the faunal component of the project area has in the past been fairly typical of that found within other estuaries of the north-central Gulf of Mexico. However, the influence of the Atchafalaya River and the Wax Lake Outlet has a more dominant effect on the fisheries of the region and has at times pushed the estuarine component far to the west and out into the gulf. This is evidenced by the periods of widely distributed fresh-water species of finfish. During this time, large numbers of centrarchids are commonly taken in seine collections, while the larger spotted gar (Lepisosteus oculatus) and blue catfish (Ictalurus furcatus) are taken in deeper waters sampled by trammel nets.

Bryan et al., (1976) has shown the dominant species of fish within the bays and open waters of the project areas to be variable, with a low faunal similarity index value between Four League, Atchafalaya, and East Cote Blanche Bays. Although the region is generally used by a very similar suite of species at approximately the same time, minor differences within the salinity and water temperature regimes of the waterbodies make each subunit of the project area more desirable for different species at different times. As an example, the bay anchovy (Anchoa mitchilli) was broadly distributed in the fall of 1975 and was the numerically dominant fish taken by seines at Little Beach Bayou, Halter Island, while the gulf menhaden (Brevoortia patronus) became the dominant species at all four stations. In the spring of 1976, the bay anchovy was once again taken at all stations and was numerically dominant at Halter Island, while the Gulf menhaden retained dominance at the other three stations. This shifting of dominance of members of the same suite of species is common within coastal estuaries.

Within the project areas, Bryan et al. (1976) has shown the most abundant eurytolerant species to be the Gulf menhaden, bay anchovy, spot,

Atlantic croaker, and sea catfish. During the summer and fall months, immigrants such as the spotted seatrout (Cynoscion nebulosus), sand seatrout (C. arenarius), leatherjacket (Oligoplites saurus), spotfin mojara (Eucinostomus argenteus), and Florida pompano (Trachinotus carolinus) use the shallow waters of the bay system.

Hoese (1976) reported on the sport and commercial finfish of the Atchafalaya Bay region based on monthly samplings of gill nets and 16-foot otter trawls (Figure D-3). His study showed an estuarine system occasionally overpowered by the fresh waters of the rivers which feed into the bay. During long periods of the study, major portions of the system were reported with salinities below 1 part per thousand (ppt). The presence of very few fish during this flood period reflects how dramatically the fauna of the bay is affected by the rivers. Hoese (p. 14) states the "Atchafalaya Bay catches from November 1974 through May 1975 were practically nonexistent. This period coincided with the flood and its cool temperatures and very low salinities." Comparison of catches from the Atchafalaya and Vermilion Bays showed the fish of the latter to be much more abundant. He states "Total catch of fishes were much less in Atchafalaya Bay even not including the poor catches in the 1975 spring period. Even removing these poor months the Vermilion Bay catch was about three times as much" (p. 15). Catches of freshwater fish and invertebrates, however, were much more common in Atchafalaya Bay than in Vermilion Bay. This disparity was summarized by the comparison of the average number of individuals per trawl in the study period. Catches in Vermilion Bay averaged 557 fish per trawl, Cote Blanche Bays averaged 350, and the Atchafalaya Bay averaged only 109 individuals per trawl.

Hoese (1976) reported 34 species of finfish from East and West Cote Blanche Bays. Although the relative abundance of the species varied from month to month, overall dominant species included the Atlantic croaker (Micropogonias undulatus), bay anchovy, blue catfish, sand seatrout, hogchoker (Trinectes maculatus), and sea catfish (Arius felis). Fish reported as the most abundant within the Atchafalaya Bay are in close agreement with the above-noted species. However, two additional species,

the Gulf menhaden and the gizzard shad (Dorosoma cepedianum) also figured prominently in the species list. Invertebrates noted as abundant by Hoese (1976) are the blue crab (Callinectes sapidus), brown shrimp (Penaeus setiferus), and the freshwater river shrimp (Macrobrachium ohione).

Gulf South Research Institute (1977) reported 47 species of finfish and 10 species of invertebrates from stations within the project area and immediately adjacent waters (Figure D-4). The stations occupied during that study were roughly distributed with 1 in Southwest Pass, 3 in the lower portions of East Cote Blanche Bay, 2 in the southern portions of the Atchafalaya Bay, 1 in the mouth of Four League Bay, and 4 in the inshore waters adjacent to the Atchafalaya Bay. As with most reports concerning the fishes of the north-central Gulf of Mexico estuaries, some of the most abundant of the finfish were found to be sea catfish, Atlantic croaker, Gulf menhaden, and sand seatrout. Other less abundant estuarine and marine species were Atlantic spadefish (Chaetodipterus faber), black drum (Pogonias cromis), silver perch (Bairdiella chrysura), and gafftopsail catfish (Bagre marinus). In areas heavily influenced by the fresh waters of the Atchafalaya River, Blue catfish were recorded in large numbers.

The GSRI (1977) study reported a total of 37 species of invertebrates (exclusive of benthos) to be expected or as reported from the project area and adjacent waters. That study collected only ten of these species during the fish sampling efforts which were treated separately in the report on the region. The most abundant invertebrates taken were blue crab, brown shrimp, white shrimp (Penaeus aztecus), brief squid (Lolliguncula brevis), and a parasitic isopod (Aega sp.). During high periods of fresh water inflow, the river shrimp was locally abundant.

Perret et al., (1971) reported on the fish gathered during the Cooperative Gulf of Mexico Estuarine Inventory Study, a broad-based survey of the estuarine resources of Louisiana. Only three stations were located within the project area of this document, although three

additional stations were positioned in the western sections of Vermilion Bay. Results of the study were not presented on a station-by-station basis, so no analysis of the data beyond that presented by the authors is possible. However, the authors have reported 90 species of commercial and non-commercial vertebrates and invertebrates. Based on their tabularized data, the following species were shown to be numerical dominants: gulf menhaden, spot, Atlantic croaker, bay anchovy, Atlantic threadfin (Polydactylus octonemus), brown shrimp, and white shrimp.

Juneau (1975) reported on the results of a 2-year study where samples were collected at 16 stations within the Vermilion-Atchafalaya Bay complex and adjacent waters. Five of the 16 stations (Figure D-5) were located within the confines of the project area addressed within this document. However, the resultant data for the 5 pertinent stations were not presented separately in the report and no further analysis beyond that of the author can be performed.

Juneau (1975) tabularized catch data by month and discussed commercial and non-commercial species as separate groups. His data are in close agreement with those of the previously reported workers and indicate a wide variety of abundant taxa. In general, the same species reported by other workers are shown to be dominant, with bay anchovy, blue catfish, sand seatrout, spotted seatrout, Atlantic croaker, star drum (Stellifer lanceolatus), striped mullet (Mugil cephalus), Atlantic threadfin (Polydactylus octonemus), hogchokers, and southern puffers (Sphoeroides nephelus) taken in large numbers. Invertebrates most commonly encountered were the white and brown shrimp, seabob (Xiphopeneus kroyeri), roughneck shrimp (Trachypeneus constrictus), river shrimp, and blue crab. Many of this latter group were taken in juvenile or (in the case of the penaeid shrimp) post-larval stages and were periodically very abundant.

Studies on the fish and invertebrates of the adjacent waterbodies have been reported by several authors. Norden (1966) reported 84 species of finfish from the waters Vermilion Bay in a three-year study.

Seventy-five percent of the total 70,000 fish were composed of three species, bay anchovy, Atlantic croaker, and Gulf menhaden. Tarbox (1974) examined over 289,000 juvenile fish from seven sampling stations around Marsh Island, Louisiana. That author found the Bay anchovy, Gulf menhaden, and Atlantic croaker to be numerically dominant and presented life history information for all 74 species encountered during the study. Dugas (1975) reported on the results of a diurnal study which concentrated in Vermilion Bay. The most abundant species encountered during that study were Atlantic croaker, hogchoker, brown shrimp, white shrimp, and blue crab. Adkins and Bowman (1976) reported on the fish and invertebrates collected from the dredged canals of coastal Louisiana. The stations were located to the west and north of Terrebonne Bay and yielded dominant species listed as Atlantic croaker, bay anchovy, and brown shrimp. Barret et al., (1978) surveyed the "major estuaries and adjacent offshore waters" of Louisiana. No samples from this program were located within the waters of the project area, although three were positioned in Vermilion Bay and two south of Marsh Island. The predominant species encountered during the study were listed as the Gulf menhaden, bay anchovy, sea catfish, spot, Atlantic croaker, and shrimp.

One of the impacts most often associated with dredging activities of any type is turbidity. A great amount of work has been done on the effects of natural and man-induced turbidity. In nature, fish are often exposed to a range of environmental conditions from temperature and dissolved oxygen fluctuations to increased turbidity. The tolerance of such conditions varies with species, developmental stage, duration, severity of exposure, and other factors. Exposure to conditions outside the range normally encountered in the natural environment can often be tolerated for short periods of time. However, the effects of chronic exposure of populations are uncertain (Cairns, 1968; Stern and Stickle, 1978).

The response of a fish population to its environment involves a complex interaction with physical factors, and various levels of compensatory mechanisms of a species (McFadden, 1976; 1977). Sensitivity

of a population to impact imposed by an environmental stress such as dredging will depend on the age classes of the affected fish, duration of the impact, intrinsic features of the fish population, and the biological productivity and stability of the environment (McFadden, 1976; 1977).

Impacts of shell dredging on fish populations due to suspended sediments may include siltation of spawning areas affecting developmental and hatching success; reduction of efficiency of visual feeders; alteration of natural movements, behavior, or migrations; direct effects on gill tissue; and reduced food availability. Behavioral responses of fish to quantities of suspended sediments range from such specific responses as air-gulping, coughing, and scraping of body surfaces, to general increases or decreases in activity. Responses vary with species and specific experimental conditions. Reduced visibility may affect discrimination of characters necessary for sexual recognition, as well as increase concealment and therefore reduce predation on certain species (Kroger and Gutherie, 1972).

The physical and physiological effects of suspended sediments on gill tissue of adult fish has been examined and a variety of conclusions drawn. Fine particles of sediment can coat fish gills and larger particles impede water flow between gill lamellae (Nikolsky, 1963; Sherk et al., 1976). Wallen (1951) found fish exposed to 20,000 ppm of suspended sediments exhibited behavioral responses such as gulping air and floating prior to death. However, an examination of gill structures did not reveal tissue damage, although opercular cavities were clogged with sediment. Such clogging affects circulation, respiration, excretion, and salt balance (Ellis, 1937; Cordone and Kelly, 1961). Swimming in sublethal concentrations of suspended solids, as well as secretion of mucous, is thought to be effective in clearing of fish gills and permits survival in nature when exposed to such conditions (Wallen, 1951; Stern and Stickle, 1978).

Sublethal effects of exposure of gill tissue to high concentrations of suspended solids include hematological response to reduced gas

exchange at the gill surface, abrasion of gill tissue, and body epithelium (Sherk _et al._, 1974). However, the properties - physical or chemical - which elicit the above-noted response of the fish are uncertain. The number, density, size, shape, and minerology of the particles, as well as presence and form of organic matter, metalic oxide coating, and sorptive properties may be collectively or singularly important (Sherk, 1973). Juvenile fish may be more sensitive to suspended solids due to the often higher metabolic rate of juvenile fish compared to that of adults of the same species, in addition to the smaller size of gill openings (Sherk _et al._, 1975; Stern and Stickle, 1978). The most tolerant species in laboratory experiments are those whose habitat preference is the mud-water interface where suspended sediment concentrations are normally greater than in the water column (Sherk _et al._, 1975).

The effects of suspended sediments on fish larvae are uncertain. Auld and Schubel (1978) found that survival of yellow perch larvae in the laboratory following 48 to 96 hr. exposure to concentrations of suspended sediment greater than 500 mg/l was considerably reduced. However, the investigators feel that mobility of the larval fish will allow moderate amounts of sediment to be cleaned off, provided there are no toxic effects.

Packing of the gut with large amounts of sediments in fish exposed to large amounts of suspended solids has been reported (Sherk _et al._, 1974; Peddicord and McFarland, 1978). This tendency does not appear to be related to the typical feeding behavior of a species, since large amounts were found in small striped bass (50-60 mm) which are not filter or deposit feeders (Peddicord and McFarland, 1978). The effect of such sediments in the gut on continued feeding or food utilization is unknown.

Increased turbidity may interfere with initiation of feeding of fish larvae that require schooling behavior and its perception by visual cues, to stimulate feeding (Shaw 1960; 1961). The period of transition from

endogenous to exogenous food sources may be crucial as outlined earlier and may be affected in several ways by the presence of toxic substances. Laboratory rearing experiments have often shown that larval fish select food on the basis of particle size, ingesting appropriate size particles regardless of whether they are live or dead zooplankton, phytoplankton, or plastic beads. Effects may include alteration of activity and food capture behavior, change in internal cell structure and composition during starvation, as well as changes in sinking rates (Rosenthal and Alderdice, 1976). These effects in combination with reduced oxygen concentration may be substantial.

Fish may be attracted to a dredging site if the suspension of large numbers of invertebrates are associated with the operation (Viosca, 1958; Stickney, 1973; Guillory, 1982). As an example, in Lake Pontchartrain, higher trawl catch rates of gulf menhaden and Atlantic croaker occurred within 200 and 400 ft, respectively, of the dredge than at 1,400 ft or baseline (no dredging) stations (Guillory, 1982). Bay anchovy were most abundant at stations 800 ft from the dredge rather than baseline, or closer or farther from the dredge. Although it was not mentioned as a factor by Guillory (1982), avoidance of sampling gear during daylight trawling has been shown to affect catch rates in other systems. Higher catch rates in the turbid waters in the vicinity of dredging may be a function of reduced gear avoidance. Tarbox (1974) reported a negative correlation between capture of Atlantic croaker and turbidity near Marsh Island, Louisiana.

Prolonged turbidity associated with dredging operations may, in extreme circumstances, even affect the growth rates of aquatic animals. Decreased growth rates may occur if there is a reduction in food availability, or if there are increased metabolic costs due to increased searching time for available food. Increased respiration in response to environmental factors may also have an increased metabolic cost, which may ultimately affect growth rates. Environmental factors influencing growth have been classified by Fry (1971) in terms of mode of action,

primarily on metabolism. These factors are termed lethal, controlling (affecting rate), limiting (restricting supply or removal of materials required or produced), masking (modifying effects of a second factor often related to morphology), and directive (permitting or stimulating a response to particular gradient characteristic of the environment in space or time) (Fry, 1971; Brett, 1979).

In the vicinity of a dredge, dissolved oxygen concentrations are often markedly lower than ambient water (Morton, 1977; Johnston, 1981). Low dissolved oxygen concentrations in laboratory experiments have been shown to be a limiting factor for growth of fishes if all other factors are favorable (temperature, food availability, etc.) (Doudoroff and Shumway, 1970). However, translation of such data to field conditions is often inappropriate, since any single factor is not thought to be solely responsible for growth in nature (Saunders, 1963).

Turbidity-induced decreases in levels of dissolved oxygen may result in behavioral modifications or physiological changes in fish larvae (Blaxter, 1969; Doudoroff and Shumway, 1970). Oxygen uptake, as an indicator of metabolic rate, is influenced by temperature, dissolved oxygen concentration, illumination, and presence of other fish (Fry, 1971). Increased respiration rates to compensate for reduced oxygen availability may occur, although both increases and decreases have been reported (Doudoroff and Shumway, 1970). Swenson and Matson (1976) found turbidity did not affect survival or growth of lake herring larvae; however, they were more concentrated at the surface in turbid water.

Some general, often qualitative, statements about fish growth in response to turbidity have been made. The direct relationships are most often speculative, however, and are perhaps more an effect of the amount of suspended solids than an optical property of water such as turbidity.

Effects of turbidity or suspensed sediments on growth rates of common species such as Atlantic croaker, spot, and bay anchovy occurring in the

naturally turbid project area of coastal Louisiana have not been investigated. Several recent reviews summarize the current knowledge of the effects of turbidity and suspended sediments on aquatic organisms (Morton, 1977; Peddicord and McFarland, 1978; Stern and Stickle, 1978; Guillory, 1982). Based on the results of laboratory studies, investigators often conclude that ecological effects of dredging and associated turbidity are transient and minimal (Stern and Stickle, 1978). Motile organisms have the ability to avoid or vacate areas of excessive turbidities (Guillory, 1982).

Potential effects of suspended solids on planktonic and nektonic invertebrates are similar to those for fishes including physical abrasion of tissues, clogging of gills, alteration of feeding, swimming, or reproductive success or behavior. Considerably fewer studies on invertebrates exist to support these hypotheses however. Sullivan and Hancock (1977) suggest that suspended sediments may adhere to and flocculate on zooplankton, resulting in tissue damage, increased settling rates, and altered respiration and feeding. Sherk et al. (1975) hypothesized that quantities of inorganic material along with particulate food would interfere with copepod suspension feeding. In laboratory experiments, the copepod Eurytemora affinis, which normally occurs in more turbid estuarine areas, increased pumping rates in the presence of concentrations of suspended solids. This may be a reflection of the fact that in nature, suspended solids may signal the presence of food. The marine planktonic copepod, Calanus helgolandius, when exposed to "red mud" (fine grained residue resulting from extracting aluminum from bauxite), displayed reduced ability to molt through larval stages to adult, decreased growth and movement of adults, and lack of ovarian development in females (Paffenhofer, 1972).

No specific studies on effects of suspended sediments on blue crabs have been conducted. It has been suggested that brown shrimp (Penaeus aztecus) may occur in greatest numbers in more turbid areas either due to increased nutritive value of the suspended material or reduced predation (Lassuy, 1983).

Turbid water resulting from shell dredging may afford protection to motile invertebrates in an estuary (Sherk, 1973), and will affect a relatively small portion of the naturally turbid area at any given time. Crabs and shrimp may even be attracted to a dredging site to feed on the displaced invertebrates (Guillory, 1982). Investigators have concluded that ecological effects of dredging and associated turbidity are transient and minimal (Stern and Stickle, 1978).

In summary, the fishery resources of the coastal region are similar in most respects to the estuarine systems found across the north-central Gulf of Mexico. The dominant members of the community shift from fresh water to oligo-haline in response to flow from the incoming rivers. As freshwater increases, members of the low-salinity estuarine community are pushed seaward, out of Atchafalaya Bay, and into the nearshore waters of the gulf or adjacent bays. However, there is no indication that the fishery resources of the project area has been damaged or affected in any way by the operations of the shell dredges.

Benthos

Knowledge of the benthic organisms within the East Cote Blanche/Atchafalaya/Four League Bay system comes primarily from the works of Hoese (1974), Dugas (1976; 1978), and the environmental study of GSRI (1977). A great amount of work has been conducted within other estuarine systems and adjacent waterbodies of the northern Gulf of Mexico, and with certain precautions, some of these data can be applied to the study areas. However, the unique attributes of this system make direct comparisons hazardous. The developing deltas, strongly fluctuating riverine input, high sedimentation rates, and subsidence all combine to make an estuarine system with few equals in the northern Gulf of Mexico. Adjacent water- bodies along coastal Louisiana undoubtedly contain many of the same suite of species encountered within the project area. However, physical parameters may be radically different. For these reasons, the use of information from other esturine systems in the

northern Gulf of Mexico has been kept to a minimum, and a concerted effort has been made to center only on pertinent references.

Hoese (1974) made comparisons of the benthic fauna in a 12-year old dredge cut and an adjacent, undredged area (Figure D-3) in upper Four League Bay. His samples were accompanied by data on pH, turbidity, chlorides, and numerous sediment characteristics. Although his study was short-term and identified only seven species within his study area, it is the first report in this region which attempted to detail the effect of dredge cuts.

The first work performed by Dugas (1976) involved monthly collections at 14 stations within the project area over a period of 17 months (Figure D-6). That author examined in excess of 6,200 benthic organisms in his study on benthos of the region and reported 56 species representing 30 families in 4 phyla. Dugas sampled a variety of substrate types and classified the assortment of types within six categories. Species were then listed as to the frequency of occurrence on bottom types and a "preferred" sediment was listed. The only organism collected from all of the six bottom types was the clam, Rangia cuneata, while four additional species were taken from five of the different habitat types.

Taxa most frequently taken by Dugas (1976) were Limnodrilus cervix (Oligochaeta), Corophium sp. (Amphipoda), Coelotanypus sp. (Diptera), Cryptochironomus sp. (Diptera), Corbicula manilensis (Pelecypoda), Rangia cuneata (Pelecypoda), Texadina sphinctostoma (Gastopoda), and Probythinella louisianae (Gastropoda). Numerous species were taken infrequently and may be an artifact of sampling bias, as few samples were taken in certain habitat types.

High freshwater inflow from the rivers was noted by Dugas to have an immediate effect on the benthos. He stated, "changes in total numbers of taxa and organisms relative to river discharge were nearly simultaneous

AD-A181 854 OYSTER SHELL DREDGING IN ATCHAFALAYA BAY AND ADJACENT 4/4
WATERS LOUISIANA DR (U) ARMY ENGINEER DISTRICT NEW
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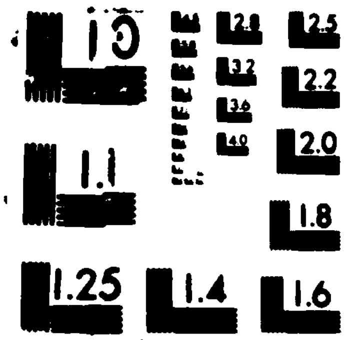
1.0
2.8
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4.0
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1.1
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1.25
1.4
1.6

Minimum numbers of taxa and organisms were collected during the early fall, low-discharge period for the rivers, while greatly increased numbers coincided with high-discharge periods. Part of this increased abundance of taxa and individuals was related to the displacement of freshwater organisms into the bays. This transport of organisms is evidenced by the fact that 11 of the 17 infrequently captured species from the study areas were classified as freshwater species.

The GSRI (1977) study reported on the benthos of the region and gathered a total of 70 invertebrates and three fish from the benthic samples (Figure D-4). That document recorded the results of stations located to sample a variety of habitat types within the coastal region. The study attempted to document the benthos at oyster reefs, adjacent mud bottoms, and a range of dredge cuts from "active" to 40 years old. Stations sampled for the report were located as follows: one at Southwest Pass, one at Mound Point, one at South Point, one at Fisherman's Reef, three at Shell Reef, one near Rabbit Island, and one near the mouth of Four League Bay. The results of the study indicated a highly dynamic system with species diversity indices ranging from 0.26 at Wax Lake Outlet to 2.40 at South Point.

During high flow periods through the Atchafalaya Basin, the water within the bay is displaced and many of the components of the freshwater, riverine fauna are introduced into the region. For this reason, an understanding of the freshwater fauna of the lower Atchafalaya River can be of value. Beck (1977) detailed the benthos of the lower Atchafalaya River Basin and listed 254 taxa representing 34 orders. Undoubtedly, this diversity is a result of the wide variety of habitat types available in the lower basin and this number of taxa would not be available or be expected to survive within the bay system, regardless of other environmental conditions. However, a large number of these organisms are flushed from the backwaters and the lower-energy streams of the basin to be deposited in the bay system. These species would be expected to survive various periods of time, depending on their tolerance and ability

to escape predators in the changed surroundings. Beck identified the detrital substrates to be the most productive of the habitats surveyed, with an average of 2,885 organisms per square meter, and 1,981 organisms per square meter found in silts.

Dugas (1978) listed a total of 76 species from 22 stations positioned from the mouth of Four League Bay, Atchafalaya Bay and East Cote Blanche Bay (Figure D-7). A thriving benthic community was identified with the major component constantly shifting from an estuarine to a freshwater dominated system, and then back again. The principal causative agent identified for this shift in the community structure was the inflow of the fresh waters of the Atchafalaya River and the Wax Lake Outlet. That author attributes the dramatic swings in the abundance of either the freshwater or estuarine components of the bay system not only to freshwater inflow, but also drastic water temperature changes due the shallowness of the water, rapid passage of frontal systems, high turbidity, and high sedimentation rates. Large volumes of freshwater introduced into the bay transport large amounts of suspended sediment while replacing the oligohaline waters with fresh waters. This shift of salinity regimes forces the more mobile elements of the estuarine community farther to the west or into the nearshore region. The flow of the cooler, fresh waters of the Atchafalaya River and Wax Lake Outlet into the semitemperate bay environment also has a similar effect on the more mobile, stenothermal elements of the benthos.

As Dugas (1978) stated, the bay is an estuarine system with a large freshwater component, dominated by few widespread species. His study indicated that species diversity increased at times of high river flow and that changes in number and densities of both fresh and brackish water organisms were intimately related to river discharge. Peak density values in excess of 4,000 per square meter were reported during high river flow and prior to the onset of low water. He showed the increase in the benthic, freshwater species is accomplished by two mechanisms. Freshwater organisms are flushed into the bay system in high numbers

during February and March, followed by limited reproduction of these displaced organisms. This displacement mechanism affects species diversity, species number, and total density of organisms within any region. His study showed that stations with peak species diversity indices were encountered in the eastern portions of Atchafalaya Bay and in the mouth of Four League Bay.

A large component of the benthic fauna of the East Cote Blanche/Atchafalaya/Four League Bay system is dominated by the freshwater organisms flushed into the bays. Two species which were found to be abundant in the basin were encountered in the bays as juveniles only. Corbicula manilensis (Pelecypoda) and Gammarus tigrinus (Amphipoda) were found only as immature forms in the bay. The dominant fresh and brackish water taxa within the coastal region are Nereis succinea (Polychaeta), Limnodrilus cervix (Oligochaeta), Probythinella louisianae (Gastropoda), Rangia cuneata (Pelecypoda), Corophium lacustre (Amphipoda), and a group of two or three species of chironomids (genus Coelotanypus). Other forms which were occasionally present in high numbers are the epifaunal species Balanus improvisus (Crustacea), B. subalbidus (Crustacea), and Mytilopsis leucophaeata (Pelecypoda).

Dupont (1984) surveyed the benthic polychaetous annelids of coastal Louisiana and summarized the literature of the group as it pertains to the region up to 1984. A single station was selected from East Cote Blanche Bay during this study, but no polychaetes were taken, although numerous stations from Vermilion Bay and adjacent regions yielded polychaetes. Dupont reported a total of 52 polychaete species from the literature and 23 species from the study collections, bringing the total species known to occur within the coastal regions of Louisiana to 56.

Works on peripheral waterbodies include that of Fontenot (1967), who studied the seasonal abundance and distribution of postlarval white and brown shrimp in Vermilion Bay and East Cote Blanche Bay. One station was located within the project area with results presented along with data

from the other seven sampling locations. However, because the study is now 20-years old and the physiography of the system has been altered tremendously since that time, little emphasis can be placed on this for site-specific information. Hebert (1968) studied the abundance and distribution of white and brown shrimp in western Vermilion Bay, and Dugas (1970) prepared on "ecological survey" of Vermilion Bay. The latter study reported 35 species from nine stations, all of which have been reported from the East Cote Blanche/Atchafalaya/Four League Bay complex. Hoese (1973) prepared a paper on the abundance of the low salinity clam Rangia cuneata in the estuarine waters of southwestern Louisiana. His study reported average abundances of the clam in East Cote Blanche Bay at 6.1 per square meter. Abundance values of the same clam were listed at 7.0 for the Atchafalaya Bay. Little information was given concerning associated species, and that author stated "Rangia apparently has no infaunal competitors in southwestern Louisiana estuaries."

The results of Hoese's (1974) work dealing with the water-quality parameters of his stations in the upper half of Four League Bay showed a definite lowering of dissolved oxygen (DO) in the waters around old dredge cuts. Conclusions drawn by Hoese indicate an accumulation of organic material was the result of the depression left behind following dredging of the trough. This depression allowed for the accumulation of organic material which demanded high amounts of oxygen for decomposition. That investigator also pointed out that this situation is not unusual and may be found in the waters of Louisiana wherever conditions allow.

The physical and chemical parameters of the sediment examined by Hoese varied little for the sediments which he generally described as soft, unconsolidated muds. The benthos of the sampled stations "were remarkably consistent" with little deviance from an average diversity of 2.4. The reader should bear in mind, however, this index may not be directly comparable to the reported values from other areas of coastal

Louisiana. Hoese's conclusion was that "Pits left after dredging become filled with unconsolidated silts and clays which as in the present case eventually become populated, so as to be eventually unrecognizable from unaltered bottom. If there are differences in the fauna due to dredging that are present after a decade they are not evident in this study. "However, he also stated that "the only large effect was exchange of a fauna associated with shell dominated by amphipods for one associated with mud dominated by clams and fly larvae" (p. 6).

The results of the GSRI (1978) study indicate a highly dynamic system with species diversity indices ranging from 0.26 at Wax Lake Outlet to 2.40 at South Point. Two "active" dredge cuts were sampled and found to have species diversity indices lower than adjacent areas. The same results were noted for one-year old, two-year old, and ten-year old dredge cuts. The single three-year old cut was roughly equivalent to the adjacent areas in species diversity. Three 40-year old cuts through the Point au Fer Reef were sampled along with three undredged areas in the immediate vicinity. Results of these samples were mixed when only species diversity is considered. One of the dredged stations had the highest diversity of this series and one of the undredged sites had the lowest.

A great deal of concern has been expressed during the scoping process over the impact of the soft, unconsolidated material known as fluid mud. Diaz and Boesch (1977) reported on the impact of fluid mud dredged material in the tidal James River and found that, in areas receiving less than about 1 foot of fluid mud, acute effects were felt primarily by insects and small Asiatic clams. The clams declined in abundance, except in areas that received less than 0.1m (about four inches) of mud. The fluid mud presented support problems for these relatively dense organisms. Within a few weeks, however, most of the species including the clams had recolonized the site to pre-dredging levels.

In terms of benthic community impact, fluid mud is regarded as intermediate between turbidity and burial by more consolidated

sediments. Unlike turbidity whose movement is controlled by local currents, fluid mud movement is controlled by gravity and tidal currents. Fluid mud begins to form at a concentration of 10 g/l and continues to be capable of fluid movement up to 175 g/l, when consolidation begins (Barnard, 1978). Nichols et al (1978) found that the fluid mud produced from disposed dredged material in the tidal James River area was very persistent, with slow reconsolidation rates. This tendency allowed the mud to spread over a larger area, and made it less capable of supporting dense organisms (e.g. clams) than the more consolidated material.

Organisms which are dependent on contact with the overlying water may not be able to survive unless they can reestablish contact (i.e. reach the fluid mud surface) before being overcome by the stresses of physical burial. Although severe dissolved oxygen depression in the referenced fluid mud sediments was short-lived, it probably contributed somewhat to total organism destruction because of its additive effect to the stresses imposed by burial. The small thicknesses of fluid mud material that would occur outside of the dredged area are not believed to be sufficient to destroy or otherwise permanently harm most of the affected benthic species, except the smallest organisms and those incapable of burrowing for short distances.

In summary, the impacts of shell dredging operations affect relatively small portions of the waterbottom at any one time, with initial stages of the recovery of the benthic community following within months. The community structure of the benthos of the project area is highly dynamic. The response of the benthos to shifting environmental conditions (e.g., increased river flow, passage of cold fronts, etc.) is very rapid, and is reflected in the community structure. Indications are that dredging activities have the effect of lowering species diversity for a period of time following the extraction of the shell resource. However, the natural responses of the benthic community to the high variability of the system probably account for wider, more drastic swings in the species diversity profile.

Oyster Reefs

Oysters of the genus Crassostrea form large concentrations of shell within the oligohaline reaches of most of the estuaries along the southeastern and gulf coasts of the United States. These "reefs" provide millions of dollars of oysters annually and a firm substrate for the settlement of the young oysters or other invertebrates. These larval oysters, or "spat", require a firm surface to metamorphose from the planktonic stage. This is accomplished by the cementing of the organism to a firm substrate. These resultant reefs are often quite extensive in regions where currents carry sufficient nutrients and are able to carry off waste products.

The reefs are composed primarily of oyster shell with attached organisms, such as mussels, clams, and worms. They were extensively mapped by Thompson in the 1940's in connection with oil company interests. The reefs became stressed with fresh water and sediment in a zone extending from Oyster Bayou to Southwest Pass approximately 50 years ago. Growth of the reef zone halted 25-30 years ago as fresh water flow and sediment loads from the Atchafalaya River rapidly increased. The reefs were impacted by the fluid muds of prodelta clays in the 1950's and more recently by the silty clays of distal bar deposits associated with the growth of the Atchafalaya Delta. However, during periods of low river flow, salinities in the project area can be elevated to a point where optimal oyster growth occurs. When this happens, massive beds of oysters are formed in areas which may not have been suitable in previous years for oyster production. Unfortunately, these reefs are often eliminated by high flows of fresh water and sediments into the area the following year. Numerous such reefs have been verified by LDWF surveys in 1986.

No detailed maps of the oyster reefs of the coastal zone exist. Old maps produced within the body of previous reports and navigational charts are badly outdated, many of which still refer to reefs which have long

since been buried or removed by shell dredgers. Thompson (1953) produced a chart (Figure D-8) which purported to show the vast oyster shell reefs of Atchafalaya and East Cote Blanche Bays. Since that time, however, large-scale changes in sedimentation rates, progradation of the Atchafalaya delta, and removal of shell resources over a 70-year period have limited the applicability of these maps.

No question exists that oyster reefs have in the past been extremely widespread and covered large areas of bay bottom. The Point-Au-Fer reef was an incredibly large barrier of oyster shells which provided protection to the Atchafalaya Bay from the full force of ocean conditions. Thompson (1953) described the reef in fairly good detail. He stated:

> "The Pt. Au Fer Shell Reef, built almost entirely of oyster shell, extends as a nearly continuous reef in an approximately straight line from Pt. Au Fer on the southeast side of Atchafalaya Bay to within 10 miles of Marsh Island (Figure 2). Having been built to the water surface from Pt. Au Fer nearly to S. W. Reef in mid-bay, the reef is most extensive on its eastern end, its width being more than one mile near Eugene Island Light. West of S. W. Reef the reef is mainly submerged, and toward Marsh Island it breaks up into widely separated bodies. The main mass of Pt. Au Fer Shell Reef is actually made up of individual reef bodies interconnected with one another for distances up to several miles. Numerous small isolated reefs ranging up to several hundred feet across occur generally on the seaward side of the main reef.
>
> Pt. Au Fer Shell Reef is a spit-shaped body primarily of organic origin which has been built down-current from Pt. Au Fer parallel to the drift of the predominantly westerly coastal and longshore currents. It may be called a barrier oyster reef since it resembles a bay barrier (Shepard, 1952)

of the sandy barrier island type in its general dimensions and in its relationship to the currents and to the nearby landmass. W. A. Price pointed out to the writer (personal communication) that a spit-like oyster reef can apparently grow in place of a sand spit or sand barrier only where the longshore current transports oyster spat, but little or no sand, which is the case in the Atchafalaya area. When a sand supply of appreciable volume is present, the bottom is too unstable, and the development of a sand spit is generally too rapid to permit reef growth."

Other less extensive oyster reefs also existed within the confines of the project area, and Thompson noted that they "extend for several miles into East Cote Blanche Bay. All are submerged except in the western end of Atchafalaya Bay. The reefs occur in definite zones which more or less parallel the Pt. Au Fer Reef." These reefs were scattered throughout the project area and were considered to be dead at the time of Thompson's report (1953).

The shell dredging industry began utilization of the extensive Point Au Fer Reef as a resource in 1914, the same year dredging for oysters in the coastal area began. At that time, the few restrictions under which operations proceeded allowed for the dredging of "dead" reefs and seven companies were so doing from 1923 to 1937. In 1937, Mr. Ackerman of the Oyster Products Company performed a survey of the oyster shell resources west of the main body of the Point Au Fer Reef. He reported shell thicknesses in excess of 15 feet, and from 1937 to 1955 the greatest bulk of the Point Au Fer Reef was dredged up. Radcliff Materials (later acquired by DRAVO Basic Materials Corporation) obtained a lease in 1955 to dredge shells in the project area. As a part of the lease agreement with the LDWF, royalties had to be paid on the lease within the Point Au Fer Reef, whether shell was removed from the region or not. This condition of the lease had the effect of encouraging the removal of shell from the Point Au Fer Reef. Dredging on the reef was halted in 1968 by the State Attorney General and the LDWF due to a controversy which had

arisen regarding the seaward boundary of the state. This outer limit is defined by a specified distance from the shore, and in this coastal region, parts of the Point Au Fer Reef were used as the southern limit of the shore. In 1973, the Louisiana Department of Justice allowed the resumption of dredging, but only on the landward side of the reef area. In 1976, the "Attorney General's Line" was drawn and certain regions were prohibited from dredging. In 1982, the lease for the removal of shell resources from the Point Au Fer Reef expired. Dredging in the Point Au Fer Reef is now prohibited and restrictions currently in place do not allow for the removal of any subaqueous oyster reefs from the region.

A great deal of work has been done on the biology of the oyster, Crassostrea, and the associated species most often encountered on the oyster reefs. Pearse and Wharton (1938) listed 138 associated species from oyster beds, while Stephenson and Stephenson (1952) listed 105 species and Wells (1961) listed 303 species. The fact that the reefs are highly productive centers of biological activity is often a function of the placement of the reef within the estuarine system and not necessarily a reflection of the vitality of the oysters themselves. The physical role of the reef itself, from a biological standpoint, is centered around the fact that it provides a hard substrate, diversity of habitat, protective covering for cryptofauna, moderation of current velocities, and conversion of massive amounts of suspended materials into edible flesh. From a physical viewpoint, the reefs composed of oyster shells may modify the hydrology and physiography of estuarine systems in three interrelated ways: 1) modification of current regimes, 2) passive change of sedimentation patterns, and 3) augmentation of sedimentation through the biodeposition of pseudofeces (Bahr and Lanier, 1981).

In their work, Bahr and Lanier (1981) summarized much of the information concerning live oyster reefs that was known up to that point. They addressed the autoecology, synecology, biological, and physical attributes of oyster reefs as they occur along the coasts of the southern United States. However, very little published information

exists concerning the value of oyster reefs that have become buried beneath many feet of silt and clay. Common sense indicated that buried reefs have very little value, from a biological sense, once they become covered with sediments and fall into the anaerobic zone.

A single, preliminary work has been attempted in the project area which could address the value of shell reefs to the benthos of the adjacent sediments surrounding them. Sikora and Sikora (1983) took several samples on top of oyster reefs, in the bottoms immediately adjacent to the reefs, and water bottoms farther away (Figure D-11). The hypothesis put forward was that even "dead" oyster reefs served a valuable function by providing a hard surface for settlement of invertebrates. A supplement to that idea was that the invertebrates that colonized the reef enriched the surrounding sediments through the transferral of organic materials via water currents into the adjacent sediments. Preliminary results from the data collected indicated that the dead reefs did indeed enrich the surrounding sediments. This "shadow" effect appeared to result from the use of the subqueous reef by the colonizing invertebrates.

Sikora and Sikora (1983) drew conclusions from these data and reported "that the density of benthic organisms increases in the vicinity of existing reefs." In areas where subqueous reefs were removed by dredging, however, "the data imply that the removal of a shell reef would diminish the attraction of fish and shrimp to the area." The authors purported to show that in the vicinity of an oyster reef, the density of benthic organisms was measurably higher than in areas where reefs had been removed, or in "baseline" areas.

As noted previously, no maps of adequate detail exist which are sufficiently current to show the extent and location of either the submerged or subaqueous shell deposits in the project area. Many of the currently available maps and navigation charts, although updated periodically, are based on surveys accomplished prior to the removal of

many of the submerged/subaqueous reefs. National Oceanic and Atmospheric Administration (NOAA) navigation chart 11351 shows an extensive reef zone along the Attorney General's Line, much of which is no longer evident above the mudline. Seventy years of continuous shell dredging and changes in the dominant physical processes of the bays has made many alterations in the amount of exposed shell.

Removal of exposed shell (that above the mud-line) in the project area was allowed up until 1982. This material was an easily accessible source of shell and was most often the first to be removed from an area. Logic dictates that with 68 years of approved access to exposed dead reefs, and the ease with which they were removed, there are probably few exposed reefs remaining. Those that do remain were probably overlooked by the shell dredging industry, were in areas where dredging was not intensive (e.g., restricted zones, shallow areas, etc.), or only recently developed. However, other factors have also contributed to the deterioration of the reef zone since the cessation of prolonged periods of vigorous oyster growth. These processes include subsidence below the mudline, burying by sedimentation, and overestimation or improper mapping of reef deposits.

The few remaining large, individual reef units are relatively stable with regard to highly localized subsidence. Since the large reefs are attached to a stable subsurface feature, they behave much like pilings under a structure, subsiding at the regional rate, but not subject to the accelerating rates associated with dewatering and compaction of recent sediments. However, smaller reefs which may form over a period of a few years of suitable environmental conditions, may be subjected to these accelerated subsidence rates.

Examination of recent bathymetric surveys show that two to four feet of sedimentation has occurred around the seaward perimeter of Atchafalaya Bay in the vicinity of the reef zone since the 1960's. However, the area between Point Au Fer and Eugene Island has been actively scoured because of the combined effects of tidal and riverine processes resulting from

the growth of the Atchafalaya Delta. This sedimentation rate, which is highly variable in the bays, may also contribute to the burial of reefs in some areas.

In reefs which persist above the mudline for an extended period of time, erosion and breakup caused by organisms burrowing into the shell for food and protection, contributes significantly to the deterioration of the "dead" reef. However, erosion is not considered an important factor in the seeming disappearance of the reefs from the project areas in recent years. The cementing of an oyster reef is strong enough to withstand hurricane- force wave energy and the time period is too short (only about 25 years) for erosion to be a significant factor in the deterioration of the reefs.

An overestimation of reef deposits or improper mapping by early investigators may have also contributed to the apparent disappearance of a portion of the reef zone. Attempts by later investigators to find any evidence of certain reef deposits lead some to wonder about the actual existence of some of the mapped deposits. However, numerous instances of broad depressions have been found where reefs were formerly mapped, indicative of shell dredging operations in the area.

The value of submerged oyster reefs is an issue which needs to be addressed. From scoping comments received during the public involvement phase of this study, it has become evident that a great many individuals feel that submerged shell reefs have an intrinsic "value". This value has been attributed to the physical characteristics of the reef. In order to address these comments, an analysis of the biological, hydrological, geological, and economic "values" of submerged reefs follows.

As noted previously, the primary value of dead shell reefs from a biological viewpoint is the presentation of a firm substrate for the attachment of other oysters and invertebrates, conversion of suspended

materials into flesh and pseudofeces, diversity of habitat for sessile and cryptofaunal invertebrates, and modification of current patterns. It would also logically follow that the hypothesis put forward by Sikora and Sikora (1983) regarding the enrichment of adjacent waterbottoms in the vicinity of oyster reefs has merit. However, all of these values become lost once the reef becomes buried under sediment and aerobic organisms no longer have access to the habitat.

From a geotechnical/geological viewpoint, shell reefs are of minimal value once they become buried under a significant overburden. The presence of submerged shell reefs in the East Cote Blanche/Atchafalaya/ Four League Bay system would, in general, have a negligible effect on the geotechnical/geological aspects of the study area. A possible exception to this statement may be that a slight reduction in the subsidence rate/potential in the immediate vicinity of a submerged reef may be seen. Even this effect would be highly dependent upon the type and character of the overlying sediments; the depth of burial of the submerged reef; and the thickness (in depth) of the submerged reef. In addition, depending on the nature of the buried environment in which the reef is located, the degree and rate of reef decay would have an impact on possible future induced subsidence. Other aspects of the value of a buried oyster reef from a geological viewpoint, such as acceleration or retardation of delta development; increasing or decreasing of erosion rates (shoreline or other) due to possible "protection" of some sort by the submerged reef; or potential for future oil and gas reservoirs are not considered important.

The value of submerged oyster reefs from a hydrological viewpoint are minimal. Shell reefs exposed above the mudline are recognized as having a major impact on the flow and tidal characteristics of many estuaries. However, when conditions are conducive to the burial of subaerial reefs, currents are no longer of sufficient force to carry significant quantities of sediments in suspension. This allows the reef to become buried, at which point the reef loses any and all effect on the hydraulics of the estuarine system.

From an economic viewpoint, an economic good is considered to be anything external to man that is inherently useful, appropriable, and relatively scarce. The submerged oyster reef does not meet these specifications. As noted above, once the reef becomes covered with an overburden of mud, it serves no identifiable, useful purpose.

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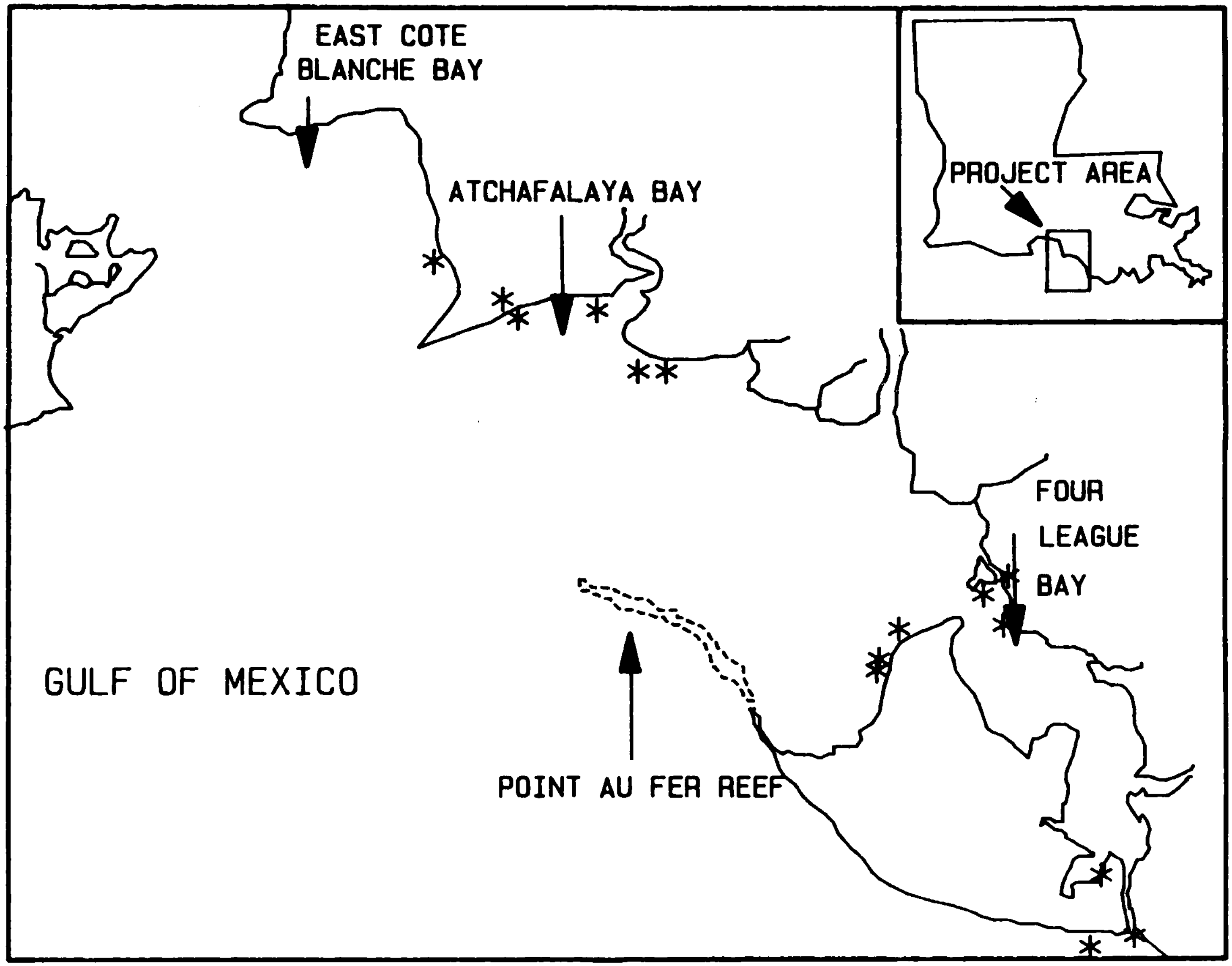

Figure D-1. Sampling Stations of Theriot (1976).

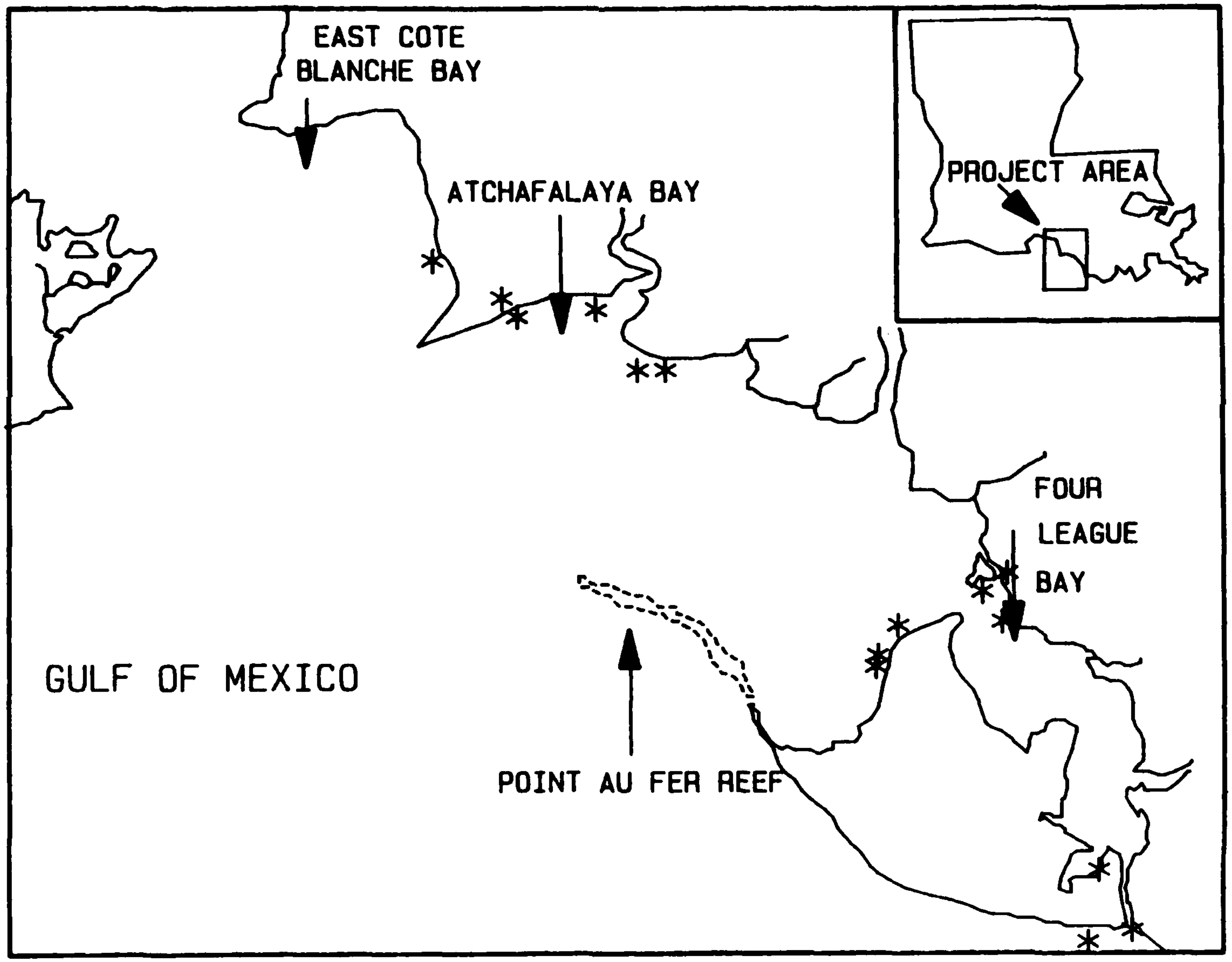

Figure D-2. Sampling Stations of Bryan _et al_.(1976).

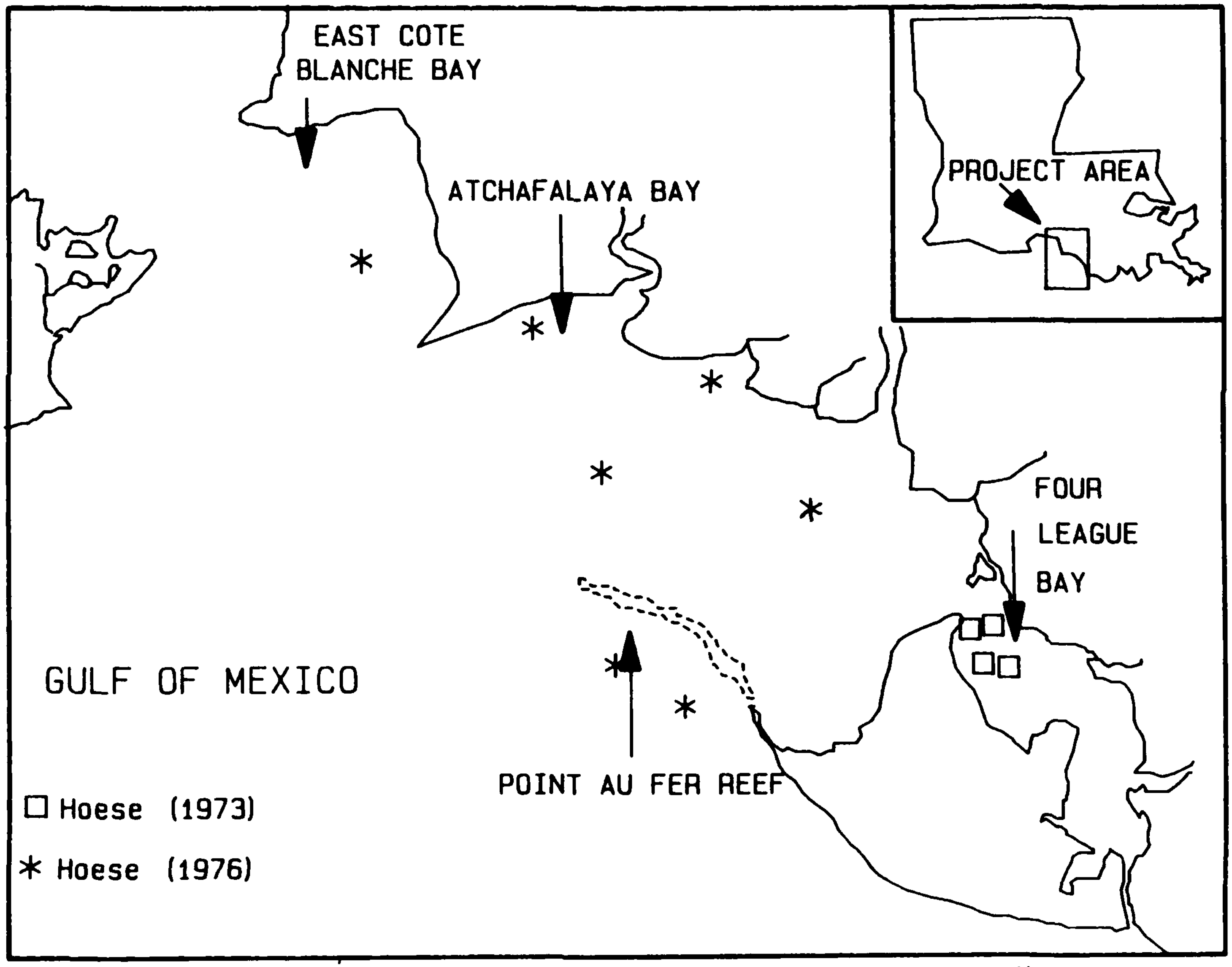

Figure D-3. Sampling sattions of Hoese (1973;1976).

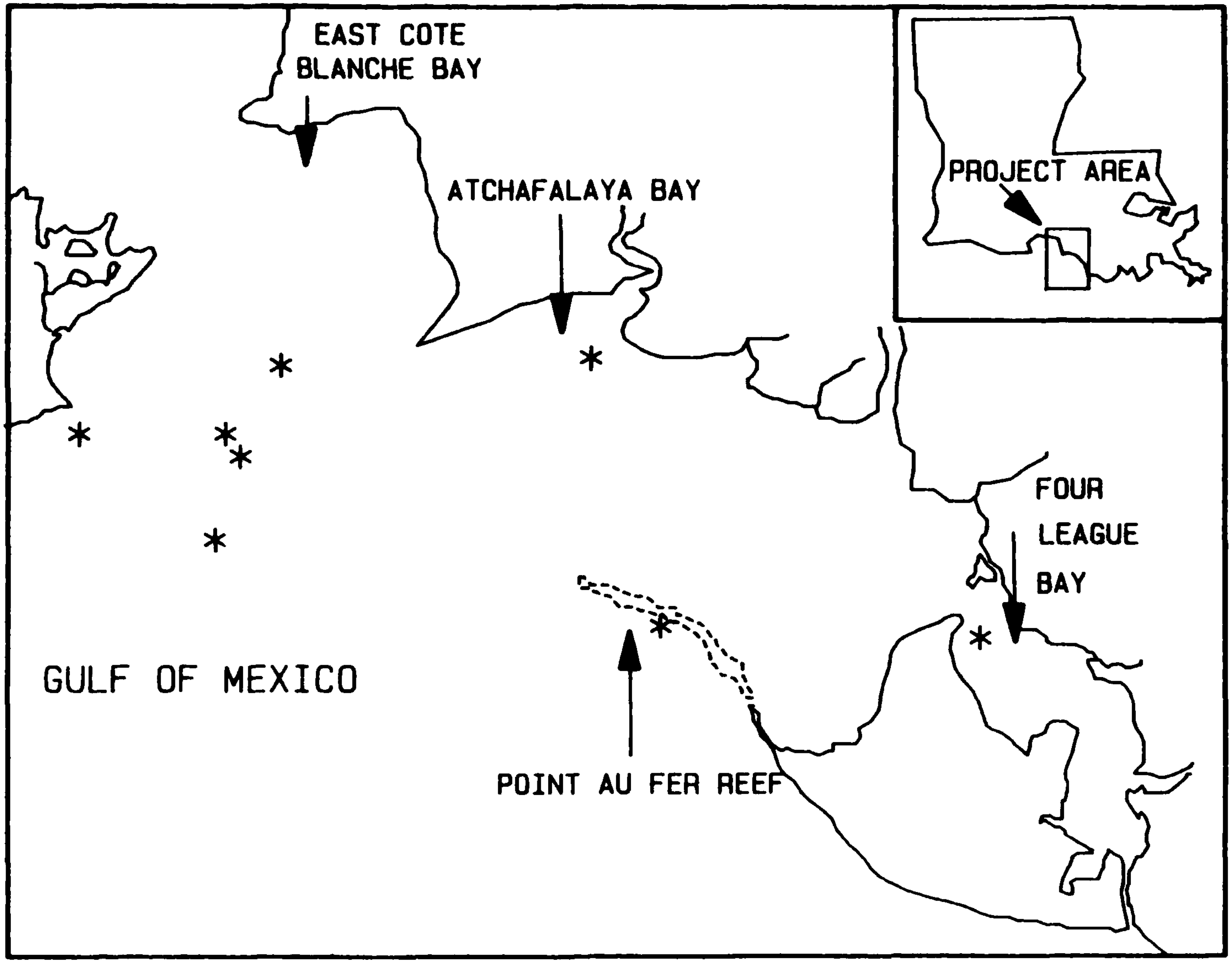

Figure D-4. Sampling Stations of GSRI (1977).

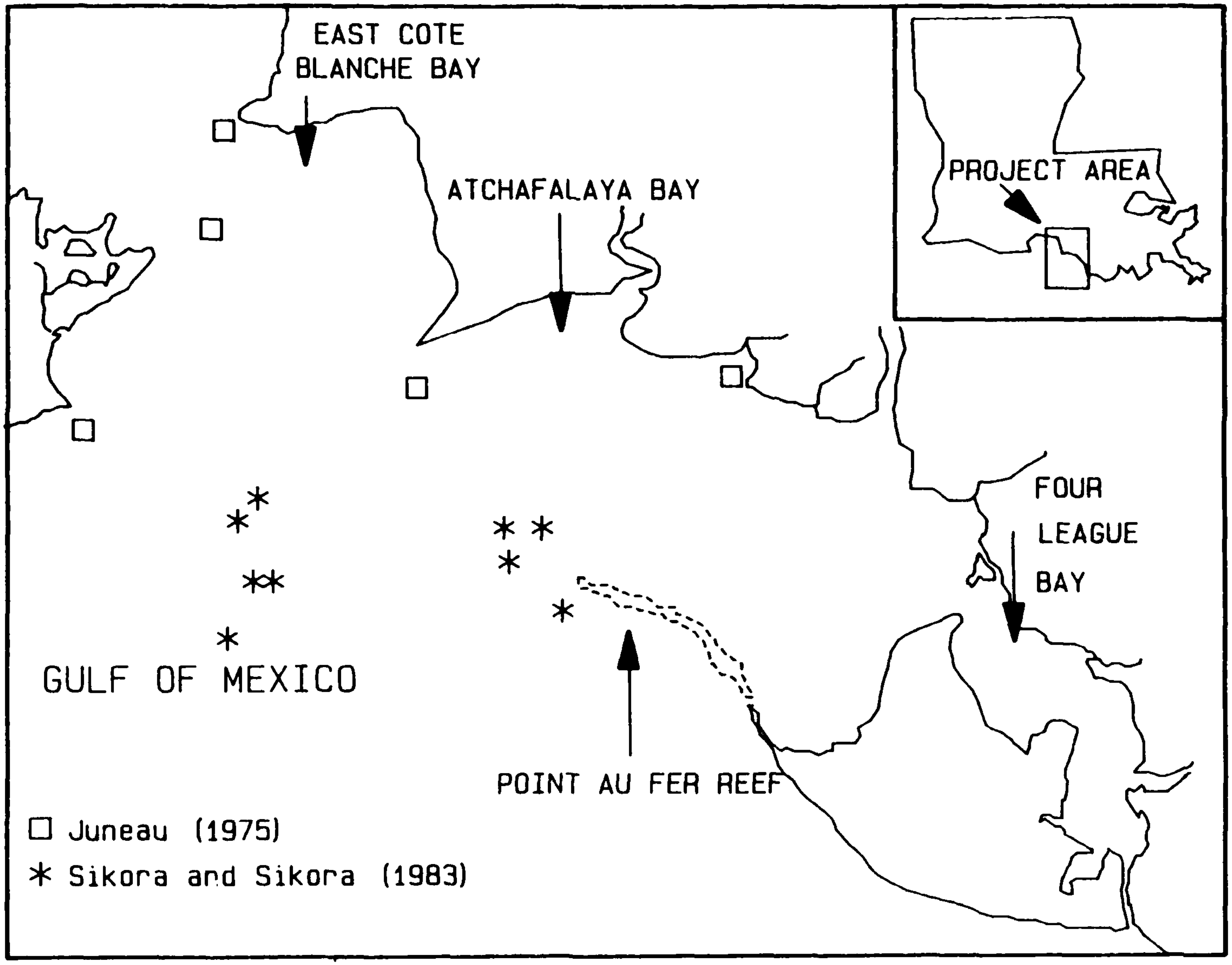

Figure D-5. Sampling Stations of Juneau (1975) and Sikora and Sikora (1983).

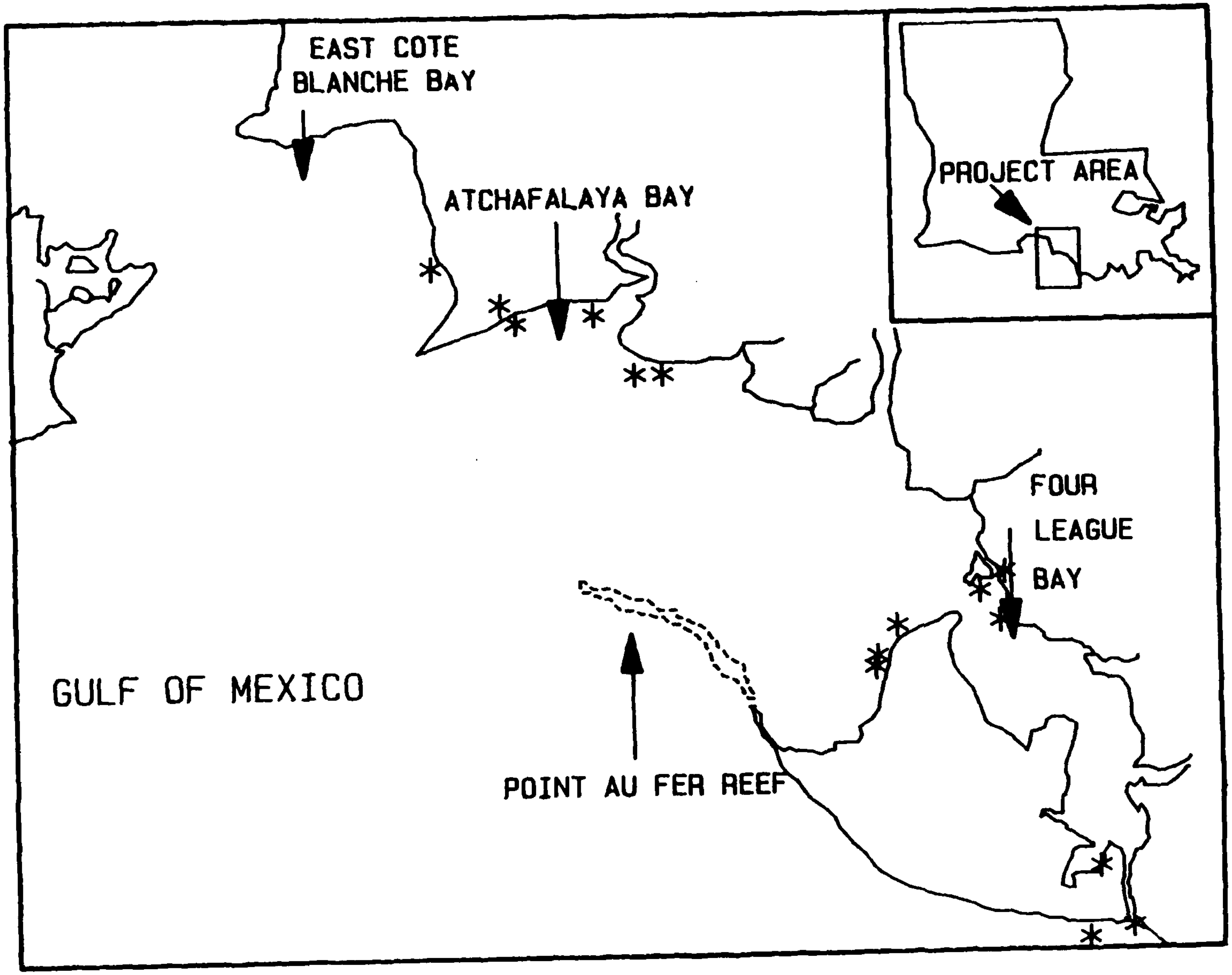

Figure D-6. Sampling Stations of Dugas (1976).

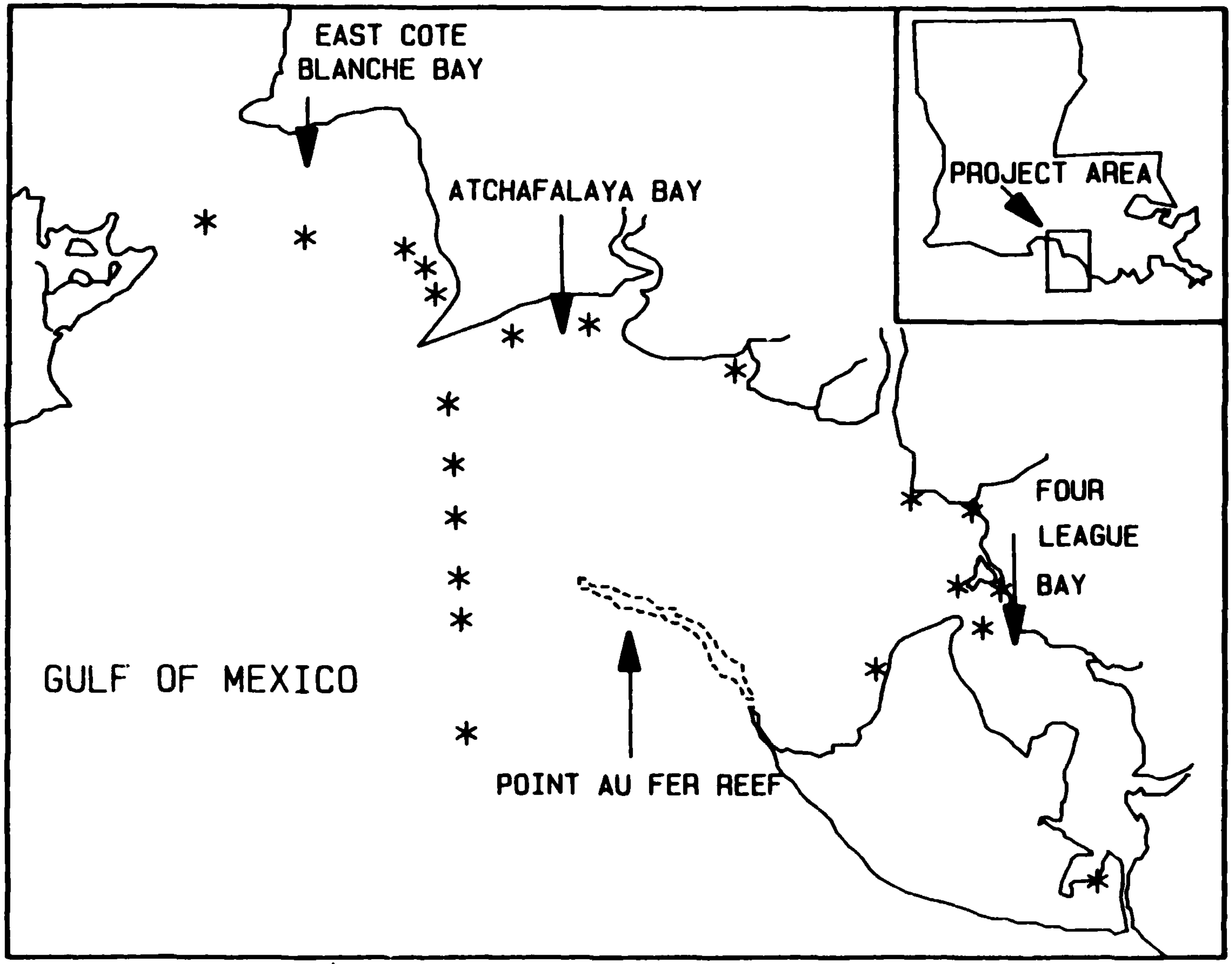

Figure D-7. Sampling Stations of Dugas (1978).

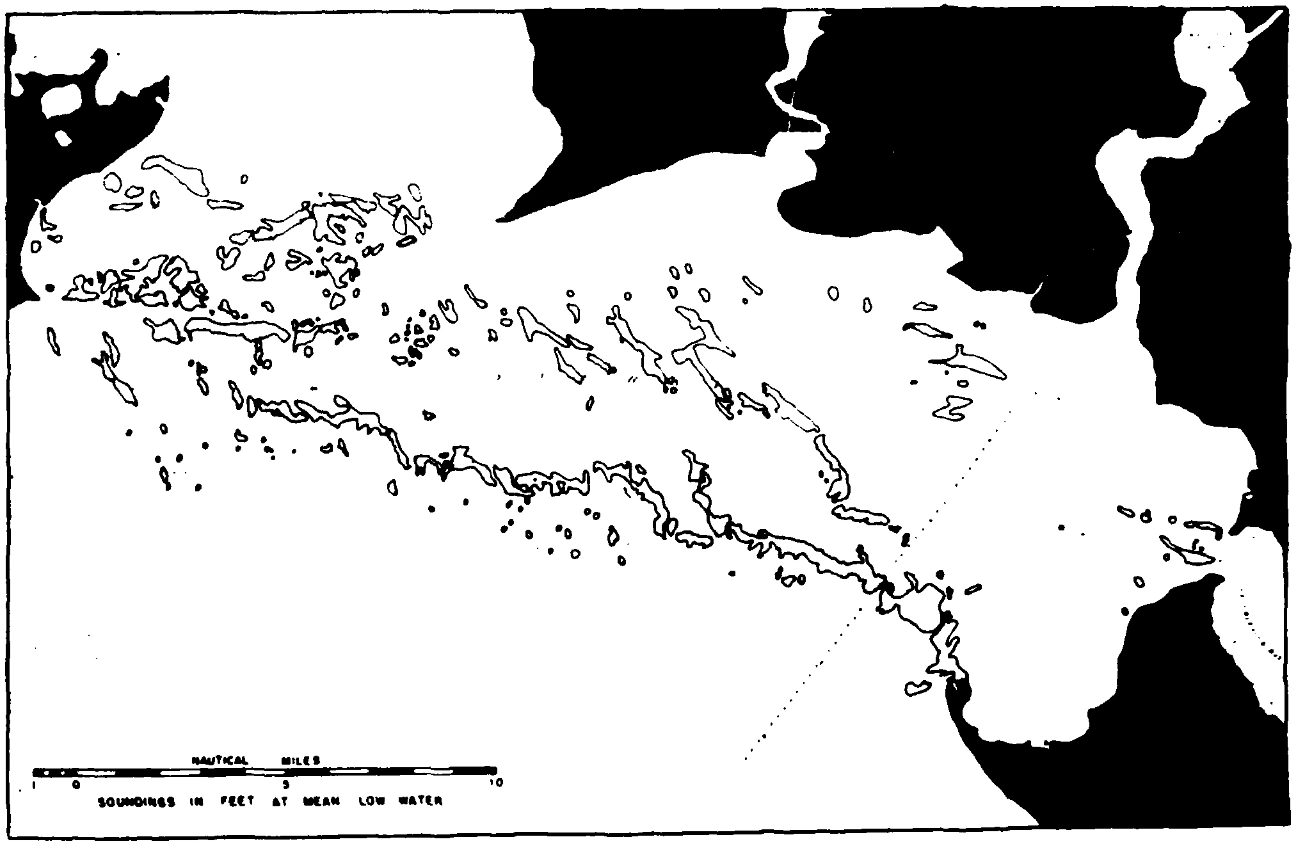

Figure D-8. Oyster reefs (open areas) as
described by Thompson (1953).

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